GEORGE F. NORDENHOLT, *Editor*

# Wartime Specifications

ARMY AND NAVY specifications are not only stringent, but often they demand a quality higher than is commercially available, or they require special features that make the product or material non-standard. This has been the reason for much caustic criticism and ridiculing of Army and Navy specifications and undoubtedly increases the time required to fill orders.

The War Department, the Army, and the Navy, are fully justified in making specifications stringent; it is their duty to demand better than commercial performance. When a new battleship, gun, tank, airplane or other machine of war is being designed, the engineers should specify everything to be the best obtainable, even a little better than the best commercial product. That is the way in which industry and science are compelled ever to improve the equipment for defense. Regardless of justifiable specific criticisms, the method has proved to be highly effective as evidenced by the results achieved. The superiority of our pursuit planes is one example.

But all this applies primarily to small sample orders such as a new pursuit ship faster than any previously built. It applies to the normal peacetime development of new and better equipment. But when the nation faces an emergency, when the immediate pressing problem is to build an Army and Navy second to none, and to do it as quickly as possible, the whole underlying philosophy governing specifications should be changed to meet the conditions.

No sane person would ever suggest that the Army and the Navy should let down their specifications to permit the acceptance of shoddy work, defective material or inferior equipment. But a great deal could be accomplished toward speeding the defense program by making the specifications in the light of commercial standards and, wherever possible, making specifications the same for both the Army and the Navy.

Admittedly, it will be a difficult task to make the specifications to meet production requirements rather than development aims. Development must not be allowed to stop, but it should be handled by a separate division or department. It will perhaps be hard to get the Army and the Navy to agree on specifications—tradition, differences in viewpoints, prejudice, and plain stubbornness are often hard to overcome. But with the proper agency empowered with the necessary authority and cooperating with industry through the medium of engineering societies, much has been done and more could be done.

As brought out at the spring meeting of the Society of Automotive Engineers, that organization is giving cooperative assistance to the Army in the development of truck, tank and other automotive specifications. The various committees of the American Society for Testing Materials are logical media for passing on materials specifications. Some A.S.T.M. committees have given invaluable cooperation in establishing such specifications. The American Chemical Society, the American Institute of Civil Engineers, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Welding Society are a few more of the outstanding organizations that could contribute greatly to speeding the defense program by cooperating in the modifying of specifications from a peacetime development basis to a wartime production basis. The National Defense Commission and the various government departments should not hesitate to call upon these engineering societies for unstinted assistance.

# HIGH-SPEED PHOTOGRAPHY

## *Applied to the Study of Machine Performance*

E. M. WATSON
*Electrical Engineer, General Electric Company*

*E. M. Watson, the author, taking a high-speed moving picture in one of the G.E. laboratories*

CLEARANCES, backlash and deflections caused by loads, inertia and centrifugal forces usually cause the movement of a machine running at full speed to differ materially from the relative positions of the various elements of the machine when standing still or when turning over at slow speeds. It is for this reason that much important design data can often be obtained by means of "frozen-motion" studies. Although the many amazing "frozen-motion" pictures, such as that of Bobby Jones swinging a golf club, have evoked much comment, and although the principle of "frozen motion," and slow-motion pictures has been used by some designers to study their machines, it seems that the great design possibilities afforded by such studies are not widely appreciated.

Perhaps the main reason more use is not made of the stroboscope, high-speed movies, and single and multiple-flash photographs, is because of the all too general impression that such studies are applicable only to complicated high-speed machinery. That this is not true has been proved by the many valuable studies made upon such relatively simple and slow-moving machines as punch presses, milling machines and hydraulic presses. High-speed movies of punch

press operations at plants of the General Electric Company have revealed erratic press operations caused by excessive deflections and clearances, and have made possible the correction of the faults, with the result that both the quantity and quality of the press production were increased.

Operating faults and design deficiencies that can be revealed by the stroboscope, flash pictures, or high-speed movies include the following: (1) cam and follower not in constant contact; (2) excessive clearances; (3) surging in springs; (4) two connected elements "out of step" because of excessive deflections; (5) excessive deflections causing interference between moving members; (6) inertia causing impact and noise; (7) improper timing as in valve actions; (8) excessive stresses as evidenced by excessive deflections; (9) erratic operations.

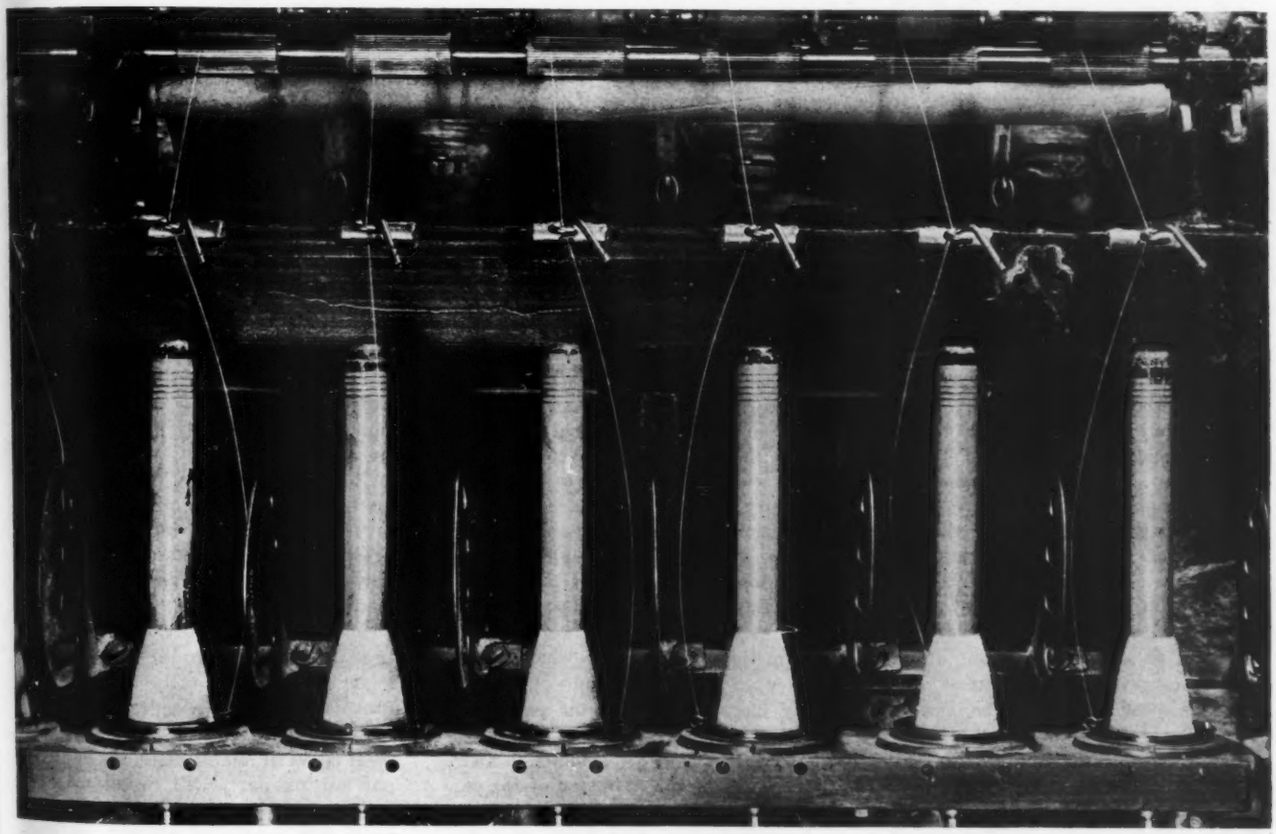
Of the several methods for investigating the functioning of a machine, the stroboscope is the simplest and quickest and involves the least expenditure. Practically the only cost is the initial cost of the equipment and the time required to do the investigating. The movements of the running machine can be seen "slowed down" or stopped, as desired.

Any investigation wherein the principal objective is simply to observe the motions of the various machine elements can best be made by the stroboscope, provided the speed of the moving element is more than 12 cycles per second, or 720 cycles per minute, and the motion is repetitive. At slower speeds the stroboscope becomes somewhat less satisfactory, because the persistence of vision of the human eye is about 1/10 of a second. Hence, if the time between flashes is longer than this, the image will have vanished from the retina of the eye before the next flash occurs and distracting flicker will result.

*Picture of the arc formed when a switch is opened. The flash of the arc furnishes all the light for taking the picture*

Using powerful light sources stroboscopically controlled, Dr. H. E. Edgerton, of the Massachusetts Institute of Technology, and his associates, have made successful single flash, multiple-flash and high-speed motion pictures by stroboscopic light. Considerable skill is required to take such pictures. Single flash pictures show the subject in only one position. The outstanding advantage of the multiple-flash picture, which consists of images from successive flashes imposed on the same negative, is that the picture itself is a time-distance graph of the motion. Knowing the frequency of the flashes, the elapsed time between successive images is known. When the images on a single negative overlap, or are otherwise in interference, one should resort to the use of motion pictures.

For high-speed movies the full equipment costs more than the apparatus needed for taking pictures on a single negative. Great care must be exercised in taking the pictures; the cost of the investigation will be high if unnecessary views or the wrong views are taken. This is due mainly to the cost of the photographic film which for one second's run is of the order of 25 ft. for 16 mm and 60 ft. for 35 mm film. Often it is impossible to tell if the desired ac-



*Textile spindles in action "stopped" by the flash of light from a condenser discharge*

tion has been recorded on the film in an intelligible manner, and when there is doubt of this the film should be developed and examined before continuing the test. This is to allow any errors to be corrected in the subsequent procedure.

In taking a high-speed moving picture, enough views should be obtained so that when the film is projected at normal speed, the motion can be seen plainly. Sometimes this can be accomplished with an ordinary motion picture camera in which the film is advanced intermittently. In some instances these cameras can be run as fast as eight times normal speed. For higher speeds it is necessary to employ a camera in which the film moves continuously and the image is either moved optically with the film or is allowed to remain on it by means of stroboscopic light for so short a time that there is no appreciable smearing due to its motion. Speeds of several thousand frames per second have been obtained with cameras of either of the latter types. It has been found from experience that a speed of about 1,000 frames per sec. is adequate for photographing the actions of most machines. At this speed the film, which requires only one second to pass through the camera, requires one minute to view when projected at normal speed.

Our experience in high-speed photography has been mostly with the Eastman Kodak, type II, high-speed camera, which employs a revolving plane—parallel glass plate for moving the image with the film. This camera uses 16 mm film, and when operated at a speed of 1,000 frames per sec., a 100-ft. spool will be exposed in four seconds. The right-hand eighth of each frame area on the negative is used for taking the pictures of the two timing dials of a clock which is an integral part of the moving picture machine. When the film is projected these dials are shown on the screen with the picture of the subject. The lower dial moves past the stationary reference line at one revolution per minute, and the numbers indicate seconds. The upper dial moves at one revolution per second, and the numbers indicate hundredths of seconds. The small divisions on this scale permit thousandths to be interpolated.

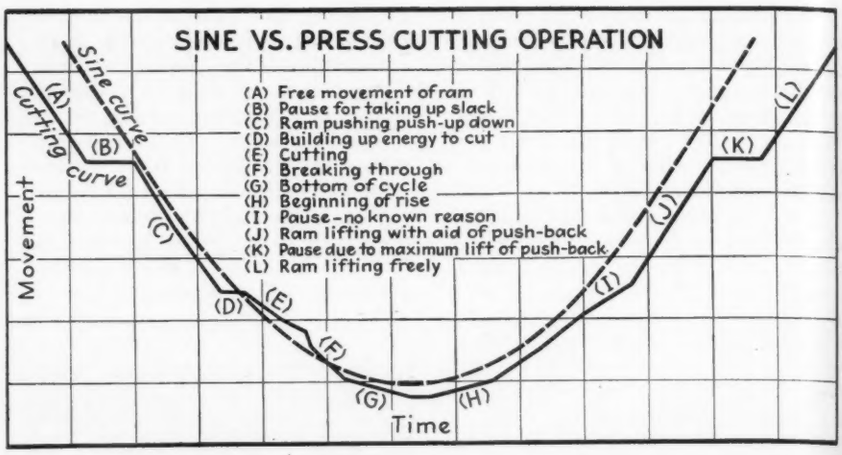
The accompanying illustrations show typical high-speed views. Pictures of this kind, to study the motions of machinery, correspond to pictures taken at lower speeds to study the motions of operators. In each case, the goal is to determine just what takes place in order that efficiency may be increased.

There are some types of machines which do not permit study by high-speed photography. Devices which have positive motion and in which the possible variations resulting from increased forces at higher speeds can amount to only a few thousandths of an inch, usually cannot be successfully studied in this way. If the working parts photographed cover an area between two inches and a foot in diameter, the sharpness of the image on the film is not sufficient to make it possible to measure movements of a few thousandths of an inch on the actual device.

Use can be made of high-speed photography for small dimensions, however, when the field of view can be limited to ½ to ¼ of an inch, in which case deflection measurements to within a few thousandths of an inch can be made with a fair degree of accuracy. Difficulty will be experienced here because the action to be considered can seldom be localized to such a small area. Some difficulty will also be encountered with lack of depth of focus when so small an area is considered. This method of analysis works out quite well when there is an opportunity for fairly large motions of the parts and, in particular, where the undesired portions of the motions amount to more than 1/100 of the diameter of the picture field, regardless of its size.

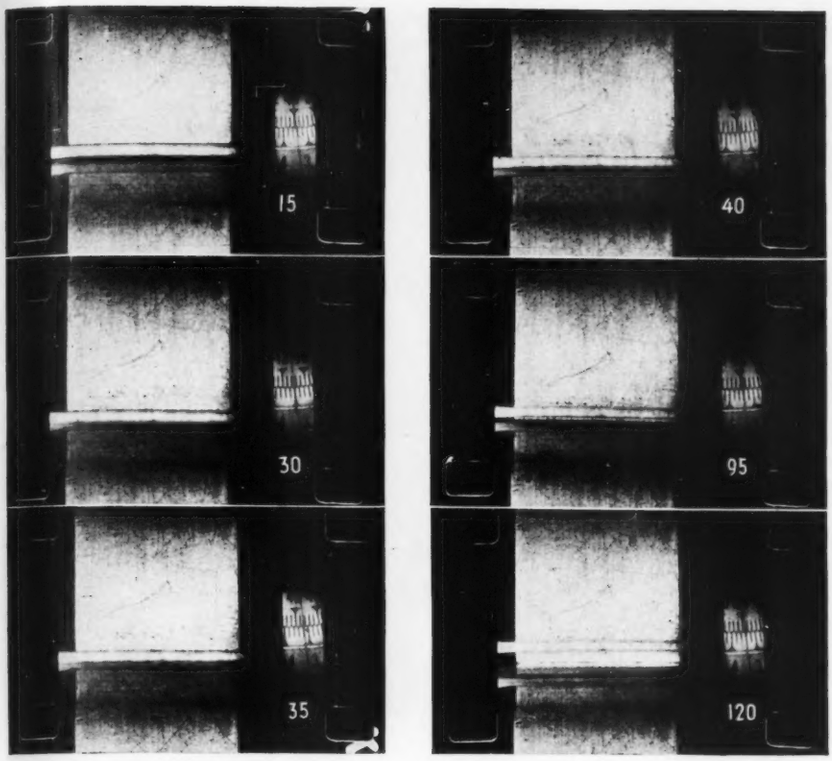
Examination of film taken of a machine moving at low speed and then at gradually higher speeds will reveal the speed at which undesired motions originate. This knowledge will be an aid to telling about how difficult it will be to correct the fault. Pictures taken at machine speeds higher than regular may reveal within a few cycles erratic operations which, at normal speed, happen only occasionally. But when they do take place, the machine may be put out of operation temporarily, as by jamming. Because the taking time is short for a large amount of film when photographing at high speeds, there is little chance of detecting errors which happen infrequently. When a clue is found, progress in obtaining the desired result can sometimes be made by redesigning the machine or even by merely making minor changes, while at other times the invention of a new device or a new method of operation may be necessary. When changes are made in a machine it is desirable to check the performance again by high-speed photography to see if the changes made are satisfactory or if further improvements are necessary.

In many machines a time-displacement curve of one or more of the principal moving parts will reveal whatever erratic behavior there may be. Such a curve can easily be made from high-speed moving pictures. A scale may be


SINE VS. PRESS CUTTING OPERATION
Sine curve
Cutting curve
Movement
Time
(A) Free movement of ram
(B) Pause for taking up slack
(C) Ram pushing push-up down
(D) Building up energy to cut
(E) Cutting
(F) Breaking through
(G) Bottom of cycle
(H) Beginning of rise
(I) Pause—no known reason
(J) Ram lifting with aid of push-back
(K) Pause due to maximum lift of push-back
(L) Ram lifting freely

*The ideal and the true time-distance graph of a crank-driven press ram*

*Eight frames numbered to indicate their relative positions in the high-speed movie strip. They show the erratic behavior during the downward movement of ram. Frame 15 shows ram higher than in frame 10, indicating that impact occurred to cause ram to rebound.*




*Frames 30, 35 and 40 show that the punch stood still from 3 sec. plus 0.410 sec. in frame 30 to 3 sec. plus 0.419 sec. in frame 40, a period of 0.009 sec. The punch has already started upward in frame 95 and in frame 120 it is shown clear of die*

placed alongside or in front of the moving element in such a manner that the element, the scale, and the time clock are photographed simultaneously. Another way is to put a dimension on a part that can be identified on the film. The time displacement curve is then plotted from the resulting pictures. It is then a simple matter to construct the velocity and acceleration curves. If the mass of the moving part or its inertia is known the accelerating forces can readily be calculated.

With further regard to the punch press, curves plotted from its operation show that the punching cycle may be divided into a number of operations, each of which has its own characteristic motions, most important of which are those taking place at the time of cutting. When the punch, die and stock all come into contact there is a delay of the punch action until sufficient pressure is developed to cause it to be pushed through the metal. The duration of this delay depends on many things, such as dimensions and condition of the punch and die, deflection of the press under load, and working characteristics of the stock.

By way of application, there are some set-ups in which manufacturing is being done where it is desired to know the manner in which different parts of a machine are functioning. In most cases it is not possible to get a picture of the punch and die in action because they are inaccessible at the time the cutting takes place. When they were designed no thought was given to taking a picture of them, and to have included facilities for a picture might impair them in other ways. Usually under these conditions about the best that can be done is to get the motion of the block in which the punch or punches are mounted. There are other important things which can be photographed, however, such as the stripper operation and the disposal of the punchings.

Over a period of time it will be found that there are some instances where high-speed photography is best for the purpose, other cases where either high-speed photography or another method may be used, and still other cases where high-speed photography is not nearly as good for the purpose as something else. The selection of the method requires consideration of many things, one of which is cost. Occasionally the coordination of a number of methods of measurement is desired. This requires some kind of a commutator which will start the camera, oscillograph and also the test, if necessary, at the proper time. Many different conditions may be recorded on the oscillograph, such as voltage, current, travel of parts, intensity of light, etc. A travel indicator similar to a rheostat would be used for large motions, and a strain gage would be used for small motions. In order to have a common starting point on both the motion picture film and the oscillogram, the clock dials may be started after the camera is under way.

Originally, the high-speed equipment was designed to allow the clock dials to be set at zero and started by some contactor remote from the camera. In photographing a race, this would permit the use of a starter's pistol with a contact on it which would be closed when the gun was fired. The dials would start when the race began, thus recording on the picture with the runners the time elapsed from the beginning of the race.

In the set-up for an industrial machine study, the clock dials would be started by the commutator after the camera was under way, and the starting current supplied by a condenser would be recorded on the oscillograph, thus tieing the two records together with a common point of time. In a set-up of this kind several trials will be necessary to make certain everything is properly timed. When the data have been obtained there is still much work to be done, consisting of the examination and plotting of what took place, in order that it may be properly interpreted.

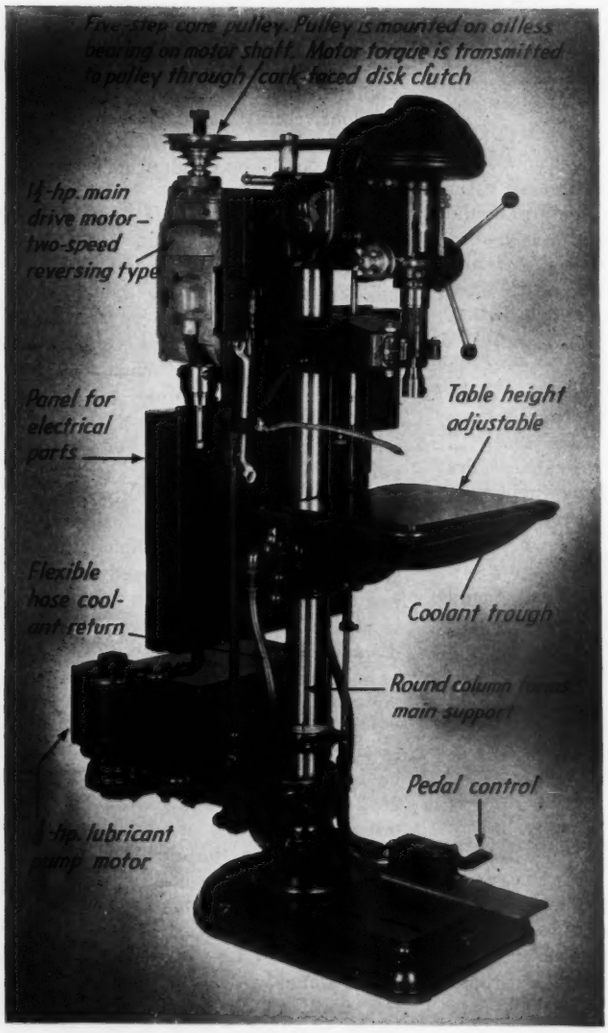
By the use of mirrors some things otherwise impossible can be accomplished. The front and side view of a mechanism can be photographed simultaneously side by side on the same frame, thus allowing measurements in three dimensions to be made with fair accuracy. It is possible to observe simultaneously performance at several widely separated places. For example, two mechanisms which are connected by shafts, or other power transmitting devices that have enough resilience to cause appreciable variations in the timing as a function of speed and load, can be investigated by this method. It is seldom possible to have the optical distances of a set-up of this kind the same, therefore, long focus lenses with adequate depth of focus should be used.

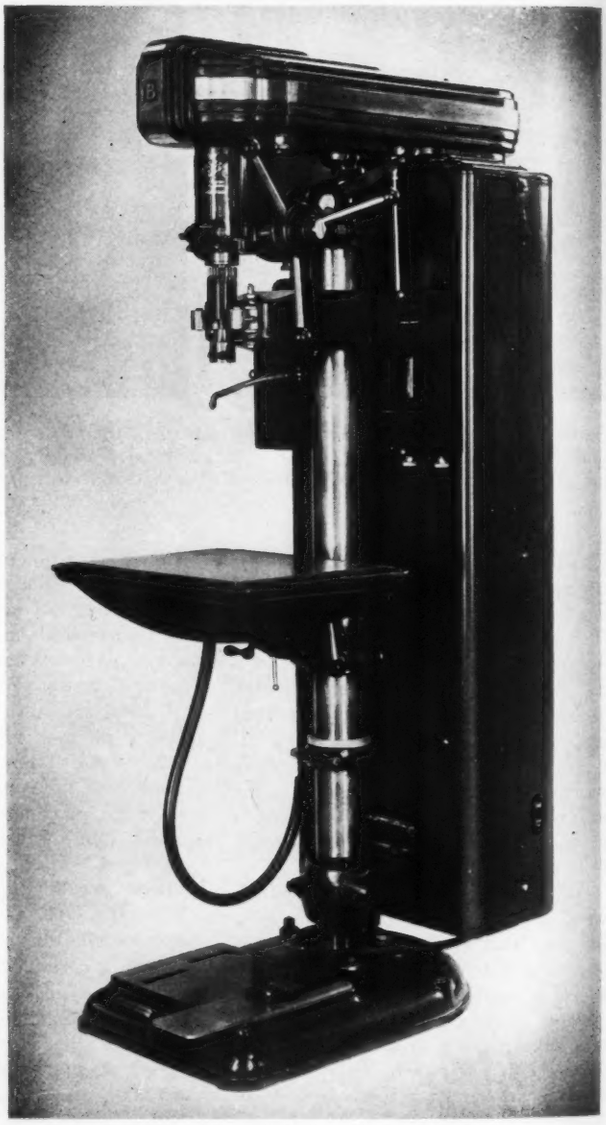
High-speed photography for the investigation of the operation of a machine is still in its infancy. It has been used extensively for determining such things as the speed of the operation of camera shutters, the operation of flash bulbs, the action of welding arcs and similar things. But the art is still too new to have been used extensively for mechanical design investigations. It unquestionably has great possibilities in this field, as has been evidenced by results obtained.

# Modern Designs

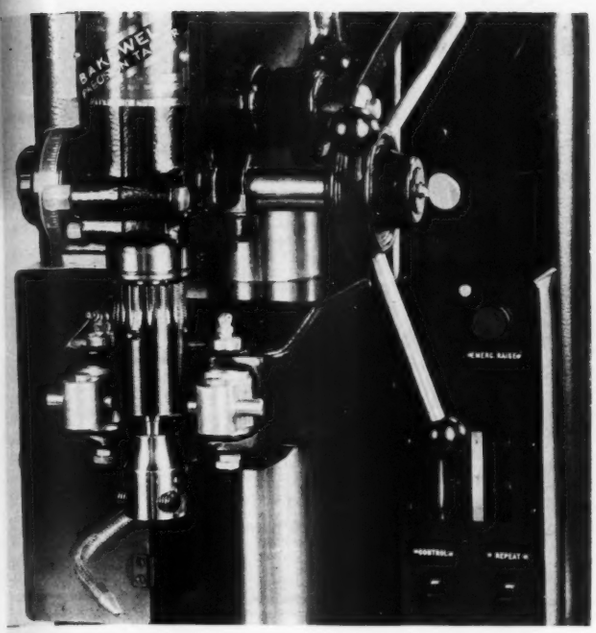
## Precision Tapper for Aircraft Work

**Since rigid Army and Navy specifications require high precision in threads, it has been difficult to machine tapped holes in aircraft parts on a high production basis because of the number of rejects. This Bakewell tapper, developed especially for high-production precision tapping, is adaptable to materials ranging from chrome-molybdenum steel to aluminum, zinc and plastics. Machine is designed so that the tap is used as a cutting tool only; it is fed and retracted by means of a combination lead screw and hob, meshing with bronze fingers attached to the main column.**

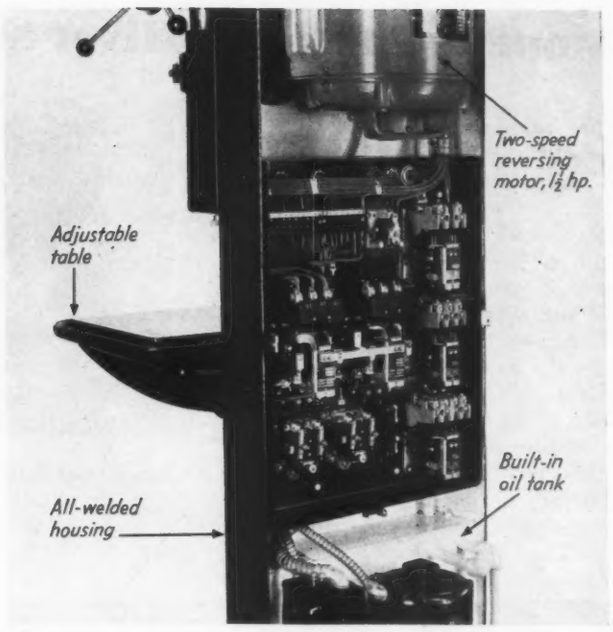

Five-step cone pulley. Pulley is mounted on oilless bearing on motor shaft. Motor torque is transmitted to pulley through cork-faced disk clutch
1½-hp. main drive motor—two-speed reversing type
Panel for electrical parts
Table height adjustable
Flexible hose coolant return
Coolant trough
Round column forms main support
Pedal control
½-hp. lubricant pump motor



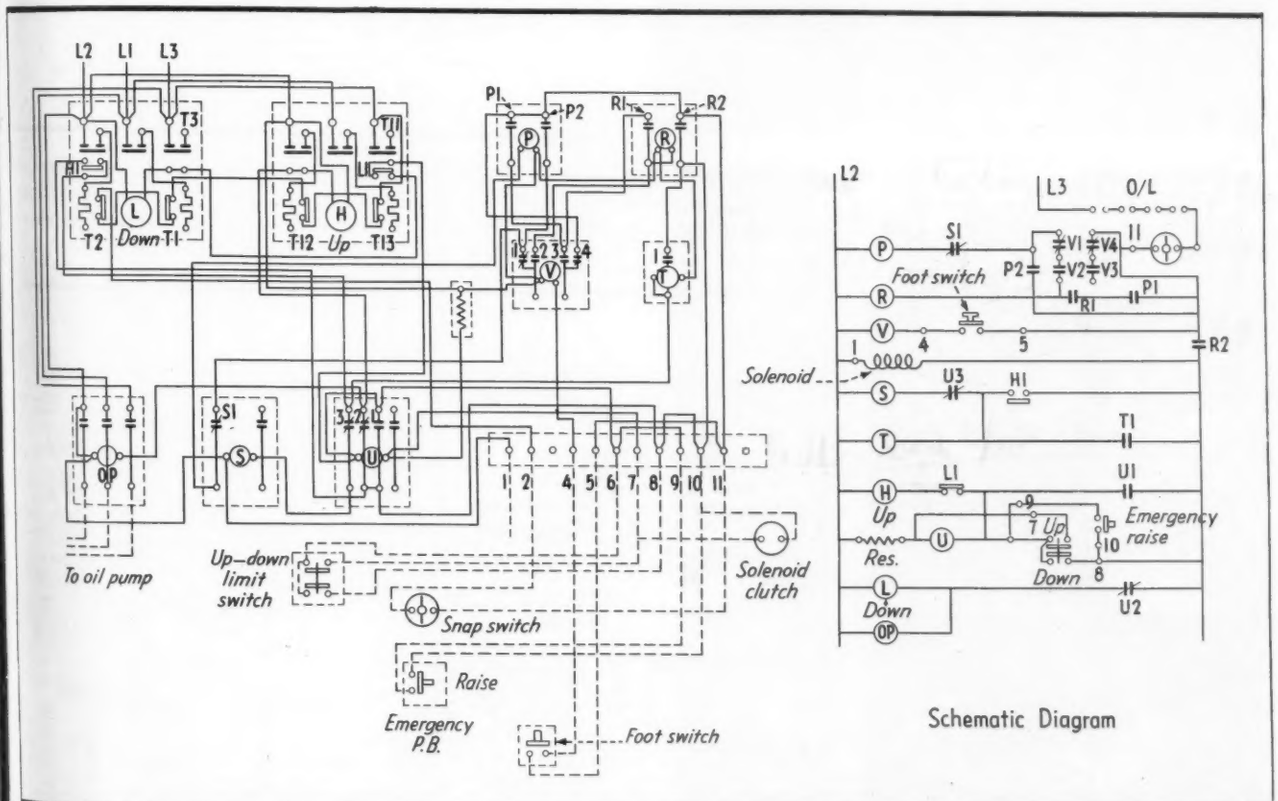
**Specially designed, two-speed reversing motor** having high-resistance rotor and extra-large frame construction drives the spindle through a five-step cone pulley and V-belts. Motor has speeds of 900 and 1,800 r.p.m. the former for feed, the latter for retracting; it is capable of 25 reversals per minute. Cone pulley is mounted on an oilless bearing and is driven through a spring-loaded, cork-faced disk clutch. If the tap becomes dull or jams, the clutch slips and the tap is reversed electrically to prevent injury to part or top. An aluminum housing protects belt and pulley.



**Lead screws** are precision ground and are machined to the same limits used by tap manufacturers. The arms holding the threaded fingers are mounted in Timken roller bearings. These arms are actuated by a solenoid through a toggle movement, engaging the fingers when the spindle is rotated and disengaging them when the tap leaves the work.



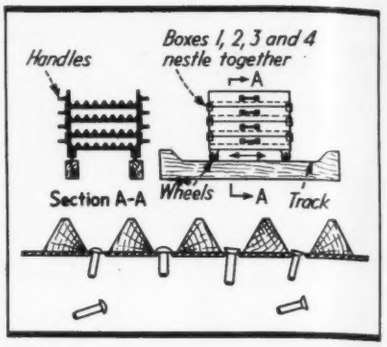

**Lubricant pump** is direct-connected to a ⅓ hp. motor, which is wired to the 900 r.p.m. circuit so that coolant is supplied only while hole is being tapped. Coolant flow stops on reversal of spindle, allowing time interval for oil to drain from parts and fixtures. Electrical equipment is mounted on rear of main supporting column in a welded steel housing.



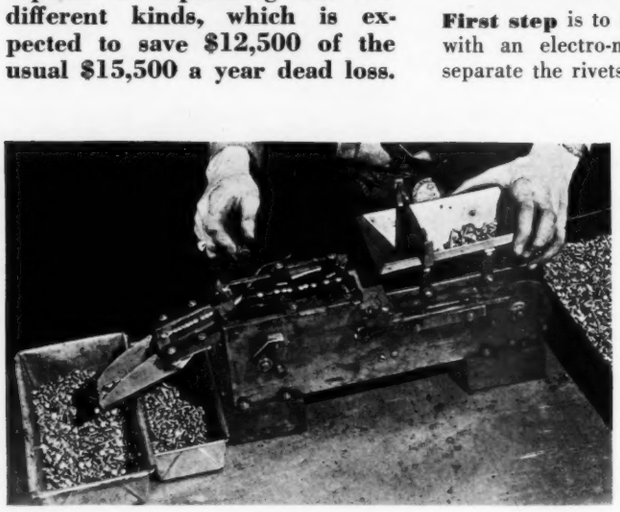

**Operation.** Handwheel feeds tap to work and foot switch closes motor circuit to give 900 r.p.m. The solenoid moves the bronze fingers, hobbed by the hob which is part of the lead screw, into positive contact with the lead screw and tap is fed to a depth predetermined by a limit switch. At this point the circuit for 1,800 r.p.m. reversed speed is energized and the tap withdraws until it contacts the upper limit switch. This stops the motor and de-energizes the solenoid, disconnecting the fingers from the lead screw so that the tap can be manually receded to clear the fixture.

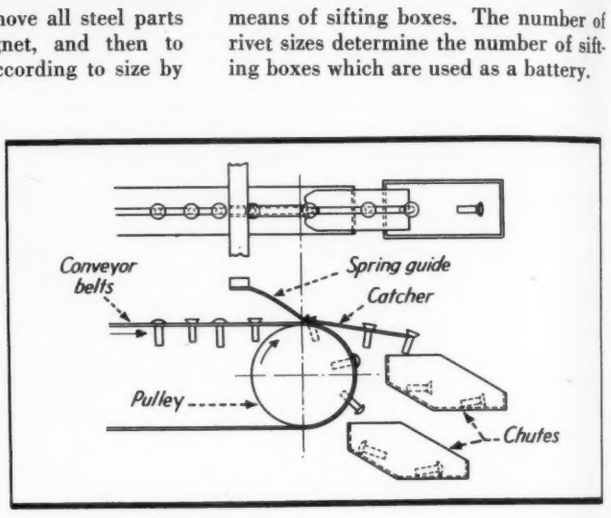
# MODERN DESIGNS – Rivet Sorting Equipment

**In airplane factories, where rivets are used by the millions, it is usually impossible to keep them from dropping on the floor and being mixed with other parts. To salvage the rivets, which represent a value of about $1.15 per pound, and to separate them by hand, costs nearly as much as to buy new rivets. Glenn L. Martin Company has devised machinery capable of separating the 150 different kinds, which is expected to save $12,500 of the usual $15,500 a year dead loss.**

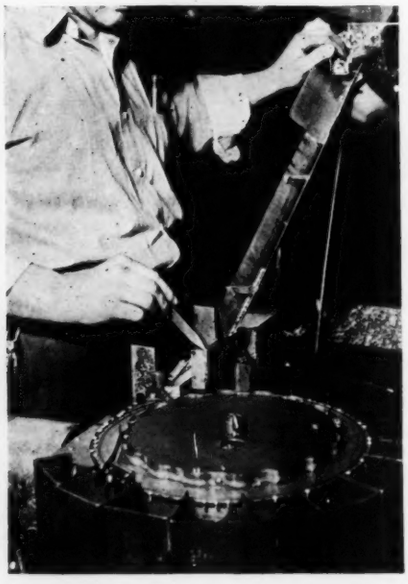


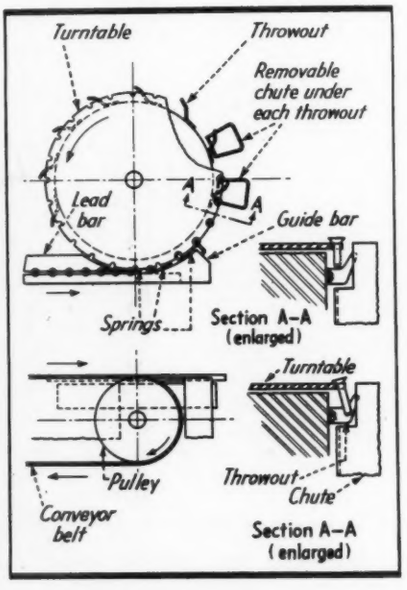

**First step** is to remove all steel parts with an electro-magnet, and then to separate the rivets according to size by means of sifting boxes. The number of rivet sizes determine the number of sifting boxes which are used as a battery.

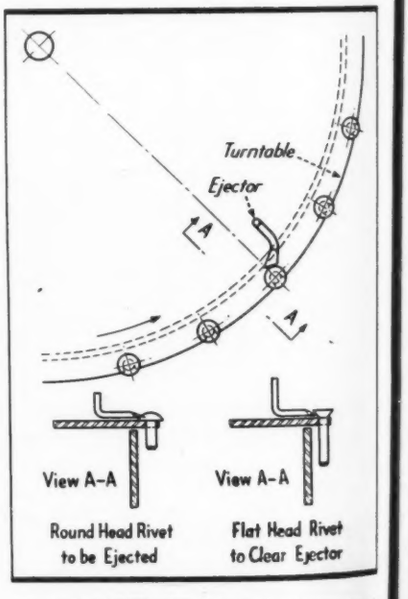





**Round heads** are separated from countersink heads by a machine in which the rivets are dropped in a hopper and placed between conveyor belts. The conveyor transports the rivets to a catcher which is so designed that the round head type rivets pass underneath and fall in a chute, while the countersink type are caught and pass above.





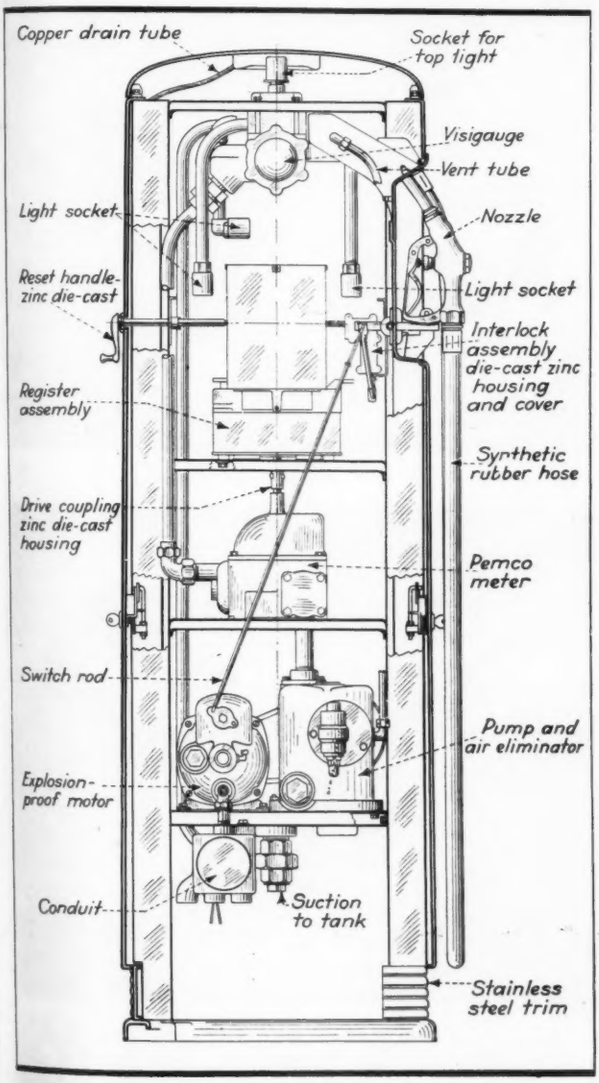

**Separating rivets** of same diameter and head as to length. A combination of springs and a guide bar transfer the rivets to the rotating table. As the table rotates the shaft of the rivets is caught by a throw-out.

**Special ejector,** installed over rotating table will throw round or countersink rivets in box, let other types pass.

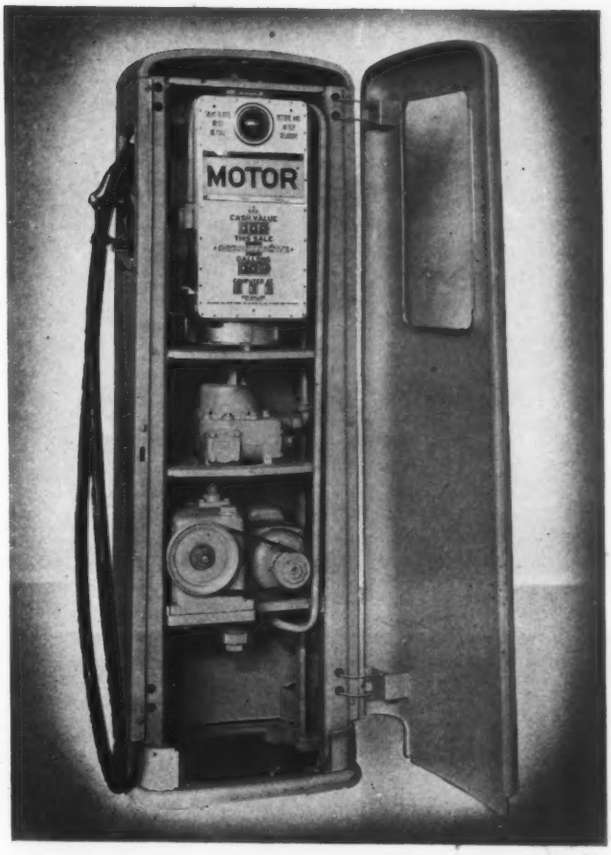
# Light-Transmitting Plastic Illuminates Dial

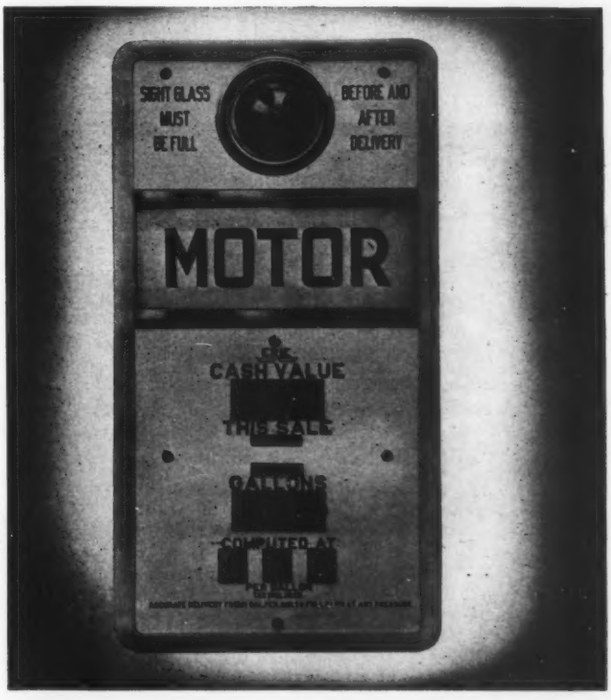
**Developed by Erie Meter Systems, Incorporated, this new gasoline pump is the first in its field to take advantage of the "light piping" properties of Lucite for dial and figure illumination. This method of detouring light into close quarters was developed by Erie Meter engineers in co-operation with the Erie Resistor Corporation, which molds the parts, and duPont plastic technicians. With elimination of the usual glass pane, it was possible to enlarge the face to 11 by 22 in.**

**Chassis** of the pump consists of four pressed-steel, channel-section columns of 0.125 in. thickness. Cross bridges, also pressed steel sections, are mounted in live rubber to absorb vibration. Housing is 16-gage, cold rolled sheet, disk sanded and Bonderized, finished with two coats of synthetic enamel baked on at 250 deg. F. for two hours.




**Pumping unit** is Erie Viking type, belt-driven and running at 850 r.p.m. It is inclosed within the air separator chamber. Pump is equipped with Veeder-Root counter.



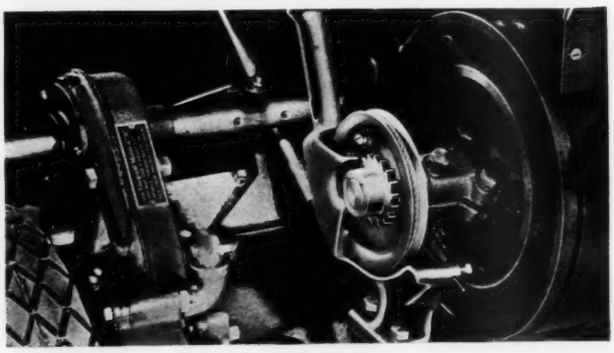



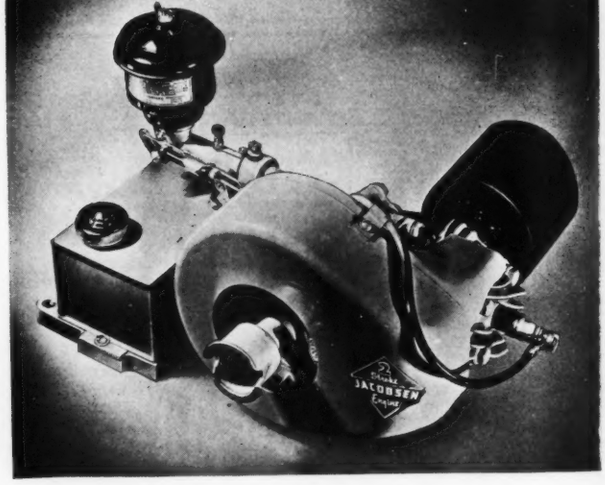

**Concealed light source** within the pump supplies light to rectangular panes of Lucite which edge-light the figures. A neon effect is obtained with Lucite outlining the dial.

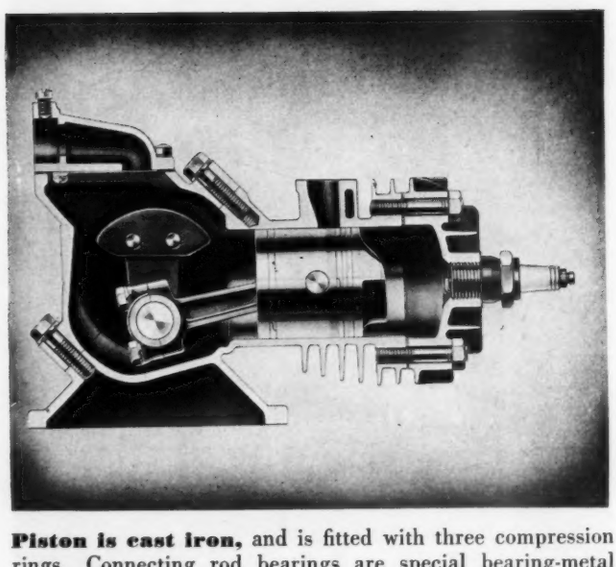
# MODERN DESIGNS – Powered by 3-4 Hp. Engine

**Reel drive from the Jacobsen horizontal engine in the Lawn Queen mower is through V-belts and a combination reel and traction clutch of the single-disk type. Clutch is asbestos-lined, adjustable for wear, and is controlled from steering handle. Reel is heat-treated crucible steel.**

**Engine has only three major moving parts**—piston, connecting rod and crankshaft, thus servicing and repairs are a minimum. Ignition is from a Wico high-tension flywheel magneto. The flywheel has integrally cast air vanes which furnish air-blast cooling. The automatic recoil starter, shown at the left, is of the over-running ratchet type. As the cable is pulled, ratchet is engaged and spins crankshaft. At end of stroke cam on starter bracket disengages ratchet pawl.





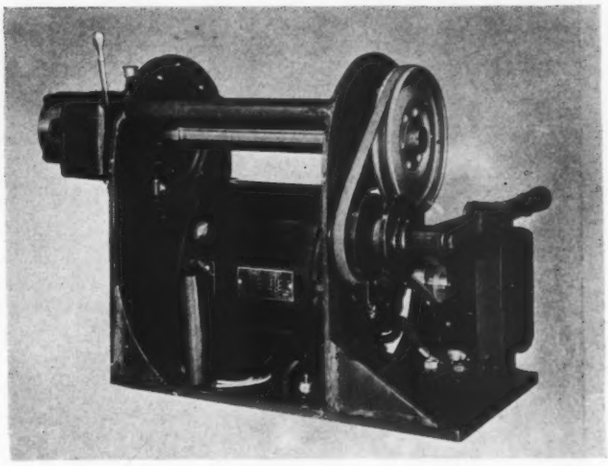



**Piston is cast iron,** and is fitted with three compression rings. Connecting rod bearings are special bearing-metal bronze alloy operating directly on the hardened and ground crankshaft and wristpin. No bearing inserts are used. Engine bore is 2 in., stroke 1½ in., rated output ¾ hp. at 1750 r.p.m. Fuel mixture is 16 parts gasoline to one part SAE 20 oil.

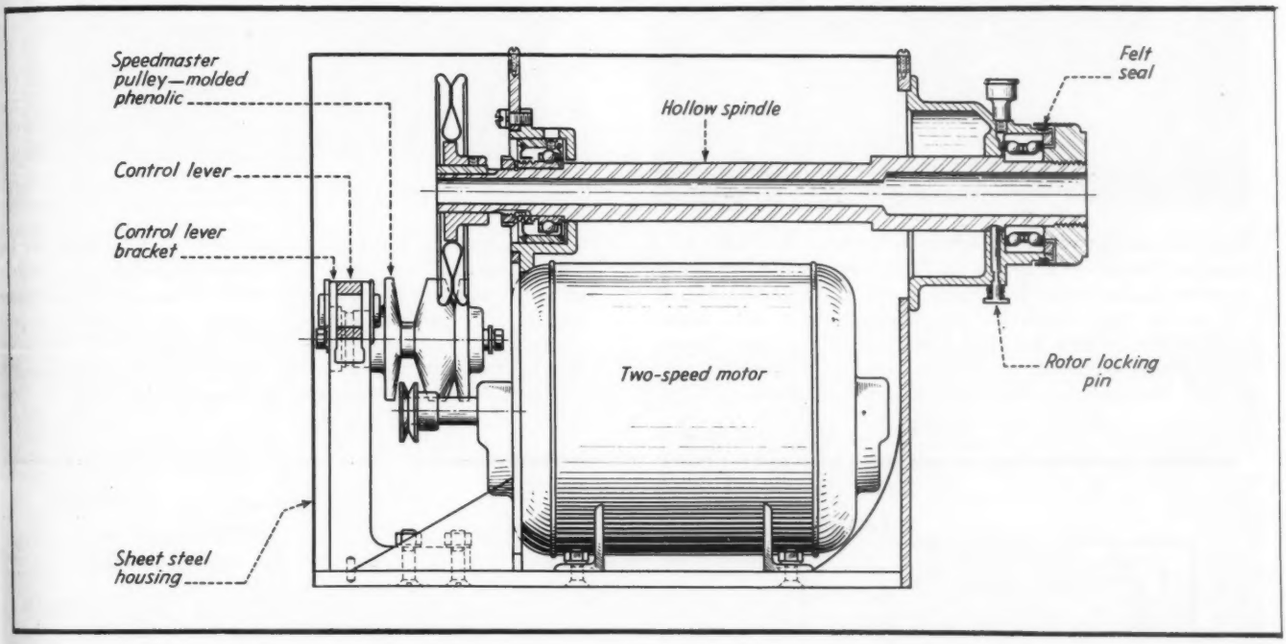
**Cylinder** and half of crankcase are cast integral of close-grained nickel-alloy iron. Crankshaft is drop-forged of alloy steel, carburized and ground. Counterweights are integral. Two Hyatt Hi-Load roller bearings support crankshaft. Leather seals protect the bearings and retain crankcase compression. Oil bath air-cleaners are standard equipment.

# Variable-Diameter Pulley for Speed Adjustment

**Designed particularly for grinding, lapping and polishing operations, the Schauer variable-speed lathe furnishes spindle speeds from 75 to 6,320 r.p.m. Range of variation is approximately 6.8 to 1 with single-speed motor, and 14 to 1 with a two-speed motor. Lathe is totally inclosed, and is equipped with easily-removed motor of standard frame size. A thermal switch and overload relay are standard equipment.**

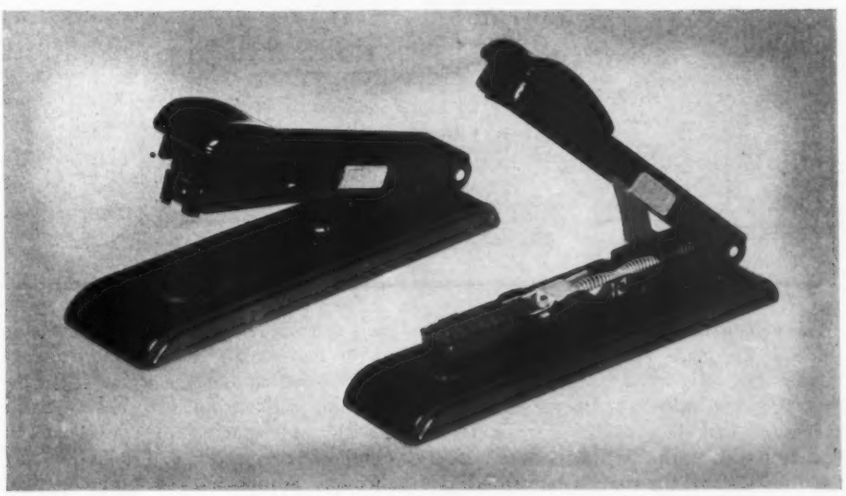


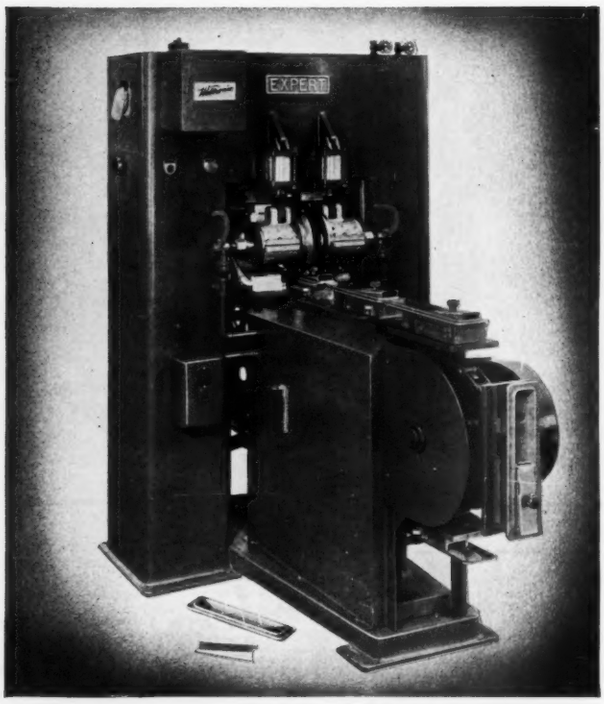
**Spindle speed** is controlled by movement of a convenient hand lever to vary the pitch diameter of the Speedmaster pulley. Adjustment of belt tension is through a movable bushing on the speed control lever. The variable-diameter pulley is molded of high-impact black Bakelite. A bronze bushing is molded in as an insert; it is lubricated through the hollow shaft and self-aligning sleeve.



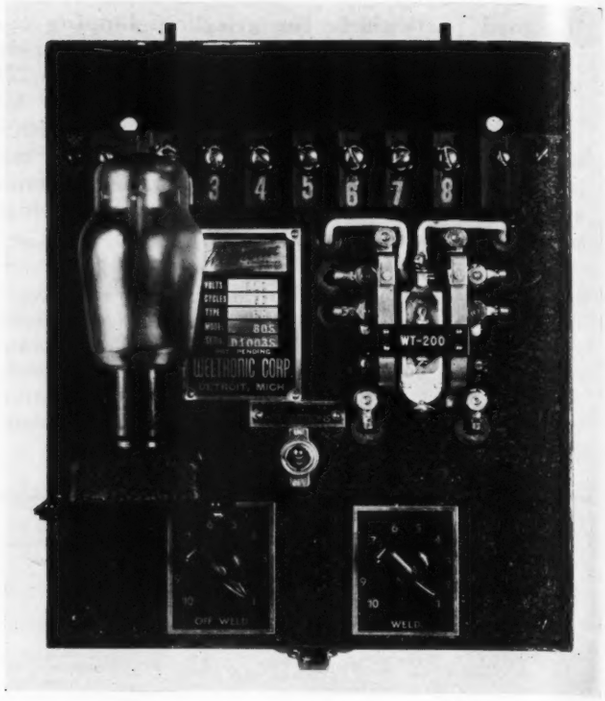

## Pocket-Size Device Adaptable to Desk, Hand-Plier or Tack Stapling

Simplified design with a minimum number of parts features the new Bostitch stapler. Working parts are steel, the plastic base is detachable. When base is detached, fastener can be held in the hand like a pair of pliers to drive staples. When the clincher blade is swung back, the machine becomes a tacker; its two-pointed staples are then driven in by applying pressure on the knob. The stapler can be locked shut, with or without base, for carrying in pocket. It is finished in wrinkle-enamel.

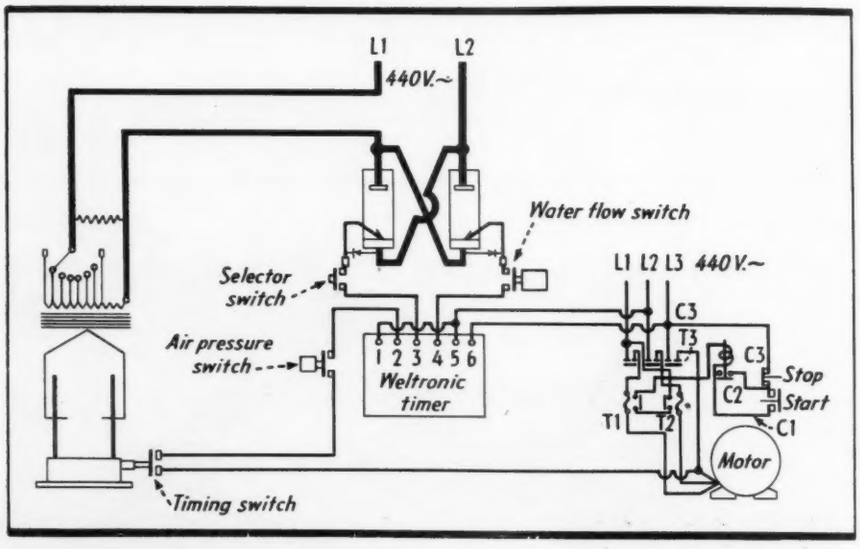





**Spot-welding with a seam-welder.** Addition of a standard Weltronic timer to an Expert seam-welder provides accurate timing control of current and an automatic repeating cycle, thus converting the machine to a spot-welder. Designed and built by Expert Welding Company, the machine makes accurately spaced spots, which can be adjusted in spacing to amount desired, irrespective of production rate.




**Timer,** built by Weltronic Corporation, has dial controls for setting current "on" and "off" time—adjustable in 1-cycle steps to from 1 to 30 cycles of current. This permits accurate control of length and spacing of spots. Interruptions repeat automatically as long as pilot switch, controlled by cam on moving die, is in "on" position. Change in conveyor speed is compensated for by changing dial setting on timer.




**Air valve** is tripped by a cam on the side of the loaded die which is carried under the rolls by a motor-driven conveyor. This valve admits air into the pressure cylinders to bring rolls into contact with work. A limit switch automatically starts the timer. After the last spot is completed, the cam on the side of the moving die releases the pressure switch, cutting out the timer and raising the rolls from the work. Same length and spacing of spots can be obtained irrespective of production rate through adjustment of timer setting.

## Random Jottings About New Developments

**Combination of strength with transparency** led to the selection of Plexiglas for the sight glasses in the McCord force feed lubricator. Ease of machining and resistance to attack by oils were also important factors.

**To retard wear,** the National Telephone Supply Company installed a set of Haynes Stellite alloy rolls on one of their wire-straightening machines. Three months after installation so little wear was evidenced on the set that ten machines were equipped with similar alloy rolls. After twelve months the rolls showed approximately 0.001 in. wear. This service wore out steel rolls in 4 months; the Stellite rolls have had a useful life of almost ten years.

# RESISTANCE HEATING UNITS

## *Their Selection and Application — Part I*

M. M. GREER
*Industrial Sales Manager, Edwin L. Wiegand Company*

RAPID progress in the development of electric resistance heating units during the past quarter century has done much to establish electricity as a worthy competitor to other sources of heat. Electric heating units properly selected on a sound engineering basis from among the wide variety of shapes, sizes, and ratings that have been developed to provide safe, convenient, reliable, and—more often than is generally recognized—economical heating, are often the solution to the heating problems. There are also to be considered the easier and more exact heat control and the many simple automatic features obtainable only in electric heating.

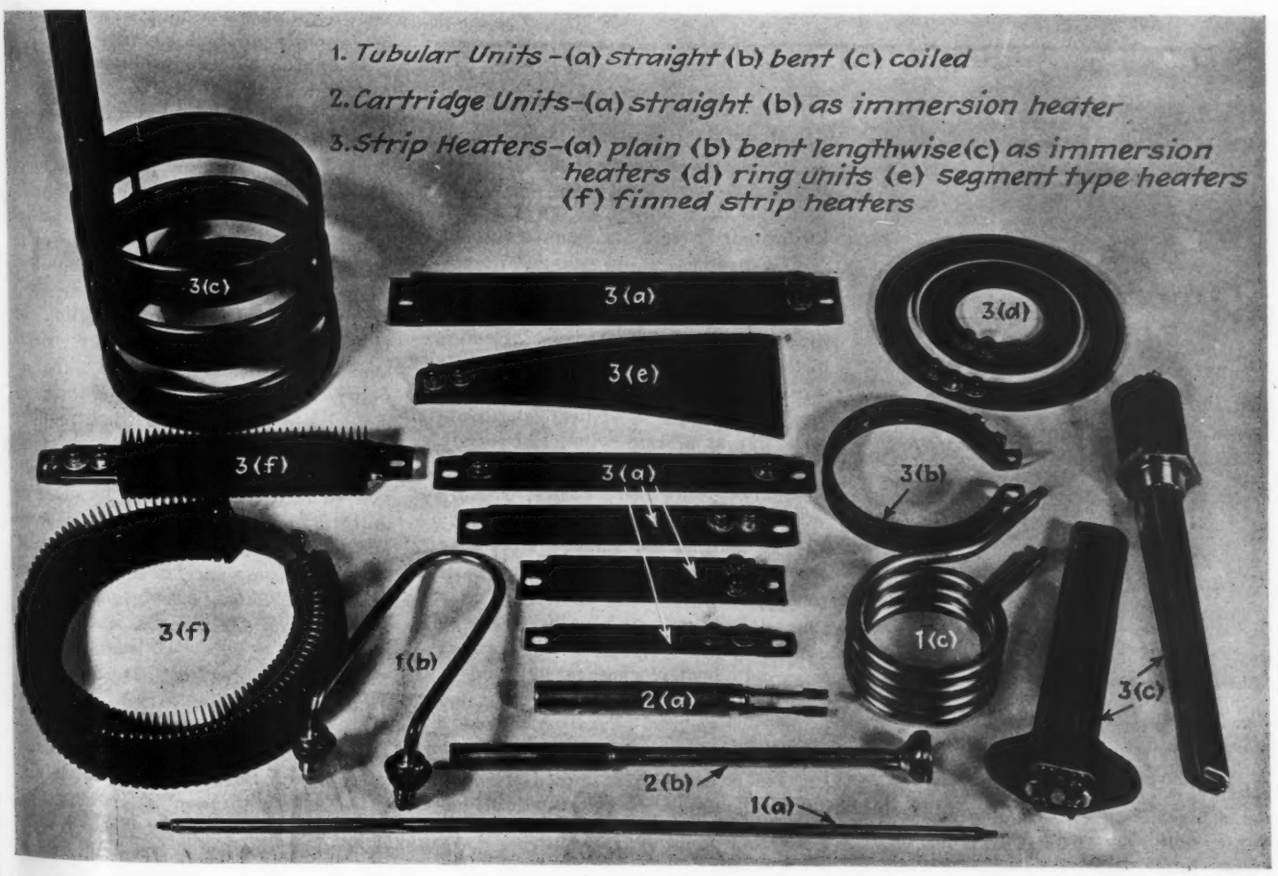
Any discussion on the selection and application of electric heating units must necessarily make mention of the available types. This article is confined to the so-called inclosed type of electric heating unit with the resistor embedded in a refractory material and incased in a metal sheath under high hydraulic pressure. Such units find application in contact heating at temperatures up to 1,000 deg. F., for convection heating of liquids and gases, and, more recently, in low temperature radiant heaters—thus including all three of the classical methods of transferring heat.

The more common types of heating elements have been derived from and may be divided into three main types or forms. Grouped according to the manner in which the resistor is wound, we have tubular units, cartridge units, and strip heaters. Each of these types has definite advantages, each because of its peculiar make-up has its physical limitations; no one type may be said to enjoy a monopoly over any particular kind of application.

Tubular units are of circular cross-section with a single resistor coil through the center of the unit. Limited to a relatively small range of diameters from about $\frac{1}{8}$ in. to $\frac{5}{8}$ in., these units can be furnished in lengths varying from a few inches to ten feet or more, and can be bent or coiled to special shapes. Typical applications find tubular units used for heating metal blocks and platens, as immersion heaters for liquids and molten metals and salts up to 1,000 deg. F., and occasionally as radiant heaters.

Cartridge units are also of circular cross-section, but the resistor is wound around a refractory core to locate the

*Fig. 1—Common types of electric resistance heating units*



## Table I—Common Types of Electric Heating Units

| Type | Form | Approx. Size Range | Typical Application |
|---|---|---|---|
| 1. Tubular unit | Circular in cross-section can be coiled or bent | $\frac{1}{16}$ to $\frac{5}{8}$ in. dia. 4 in. to 10 ft. or more in length | Immersion heaters in liquids, molten metal, and salts up to 1,000 deg. F. Localized heating in die platens, radiant heaters |
| 2. Cartridge unit | Circular cross-section cannot be bent | $\frac{3}{8}$ in. to 4 in. dia., 1 in. min. length in smaller diameters, up to 5 or 6 ft. in larger diameters | Localized heating in dies, platens, revolving rolls. Small appliances—soldering irons, etc. Immersion heaters in liquids |
| 3. Strip heaters and variations | Rectangular cross-section can be curved in cross-section for clamping lengthwise for clamping around pipes, cylindrical containers, etc. Special shapes include ring units, segment type heaters, flat-iron units | $\frac{1}{4}$ in. to $\frac{1}{16}$ in. thick, $\frac{3}{4}$ in. to $2\frac{1}{2}$ in. wide, 4 in. to 15 ft. long | Clamp-on contact heating. Finned for air heating — natural or forced convection. Oven heating. Immersion heaters brazed into flange or screw plug —single or multiple blade—coiled or straight |
| (a) Ring units—disk units | Can be formed to spherical radius for clamping to dished bottom of kettle | $2\frac{1}{4}$ in. to 11 in. dia. | Oven heaters, clamp on contact heating. Range units, hot plates |
| (b) Segment type strip heater | Can be formed to spherical radius | 9 in. to 18 in. long | Clamp-on heating cylindrical containers—process kettles |

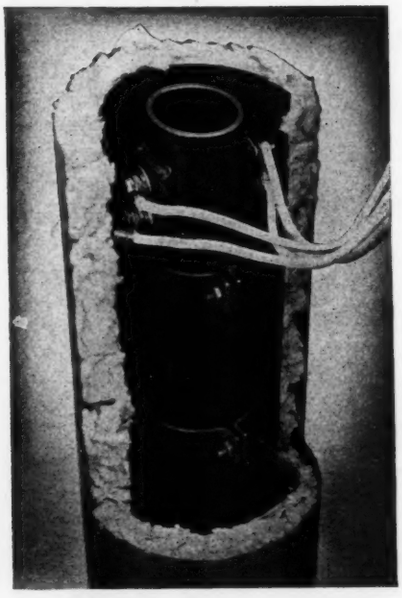


*Fig. 2—Strip heaters clamped lengthwise along pipe line. Cross-section of heater is formed to fit contour of pipe. Note clamping to insure positive contact and the air gap between insulator and elements—both important features of successful application*

coil near the inner surface of the cylindrical shell. They are available in standard sizes, ranging from $\frac{3}{8}$ in. to about 4 in. in diameter, and from 1 in. to 4 or 5 ft. in length. Cartridge units are primarily rigid and cannot be bent.

The strip heater, of rectangular cross-section with a number of coils located in the same plane, forms the basis of most industrial applications. Heaters of this type can be furnished with their cross-section curved for clamping lengthwise to pipes, or bent lengthwise for clamping around cylindrical vessels.

The ring unit, which is a special development of the strip heater, is available in diameters up to approximately 12 in., and in the smaller sizes may assume the form of a disk. Ring units can be furnished flat or formed to a spherical radius for clamping to dished bottoms of kettles, as can the segment type strip heater, another variation of the strip heater which takes its name from its shape.

Strip heaters equipped with radiating fins are used widely in forced air heating applications. Many types of immersion heaters use strip heaters as heating elements. For installing through the walls or bottom of a container, the strip heaters may be brazed or welded into screw plugs or flanges; for installing from the top of an open vessel, leads for line connections may be brought out of the liquid through risers made of pipe. The blades may be straight or coiled to specified diameter and sheath. Sheath material may be of any of a number of metals to withstand corrosive action of material being heated. A few of the more common types of units are illustrated in Fig. 1 and in Table I are further classified.

### *Selection of Units*

In Table II we have presented a suggested step-by-step procedure for the selection and installation of heating units. Each application presents a special problem and it is, of course, not possible to include in a single table all of the factors affecting the selection of units for every conceivable application. The degree of difficulty encountered in the selection is wide. The demands of one application may be met by merely opening a catalog and picking out a heater; another application may require literally months of experimentation and development before the desired results are obtained. We are concerned here with neither of these extremes, but rather with that much larger number of applications where a little thoughtful consideration will yield the rich rewards of properly applied electric heat.

In approaching the problem of selecting and applying the proper heating unit, an intelligent and complete analysis of the heating problem will go far toward simplifying the task. The mere process of writing down these requirements will often yield a better understanding of the problem and serve to guide one in his selection. This preliminary survey should include information on: Size and construction of machine, device, or container; space available for heaters, a sketch will often help; quantity and temperature of material to be processed; time requirements for initial heating, for maintaining temperature; occasional, intermittent, or continuous service; localized or uniform heating; importance of dependability, close temperature control, and similar factors; special details such as velocity of fluids, circulating systems, available voltage supply, and similar factors.

Once the problem has been well defined, the next step is to determine the required heater capacity. It will often be found that accurate calculations cannot be made and that it will be necessary to base the estimate on experience or experimental results. Usually, however, a sufficiently close

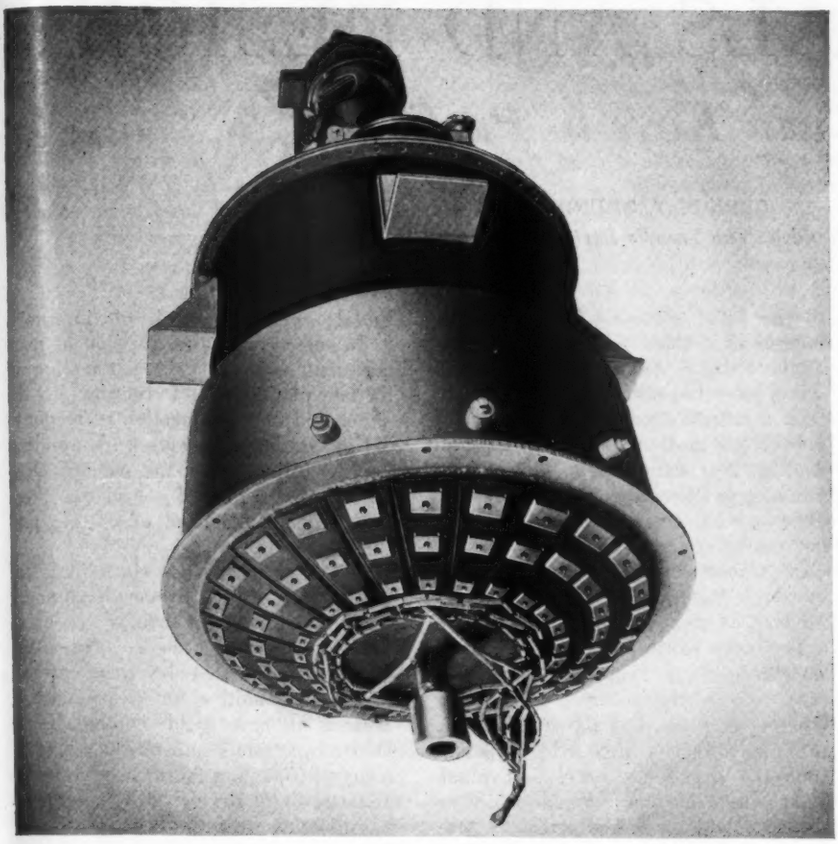


*Fig. 3—Processing tank—view from below before insulating jacket has been placed. Heat is provided by segment type strip units rigidly clamped to bottom of tank*

approximation can be obtained by basing calculations on two considerations:

1. The amount of heat necessary to bring the material—including the container, work, and associated parts—to the desired temperature within the required time.

2. The amount of heat necessary to maintain that temperature, that is, to supply the heat lost by radiation and that absorbed by the material being processed.

In most instances where heating is intermittent or occasional, it will be found that the initial heating capacity will be the determining factor; although for a long, continuous process the initial heating time is usually relatively unimportant and installations can be made on the basis of the amount of heat necessary for maintaining the working temperature. In other applications, air heating in ovens and rooms, for example, both factors are important. It is well to give proper consideration to both factors if there is a possibility that a border-line case may exist.

The most suitable type or form of heating unit is usually readily apparent, when the physical limitations of the application and those of the available heating units are considered. To cite a few examples, immersion heaters are usually employed for heating liquids; for air heating in rooms or ovens, strip heaters or some variation may be used; for electric flat irons, a special shaped unit is required.

Heat distribution is often an important factor. For localized heating in a device such as a soldering iron, a unit with a relatively small surface should be tightly clamped to the device to insure efficient transfer of heat to the region where concentration is desired. On the other hand, to provide the uniform temperature necessary for a large platen for vulcanizing rubber, the total surface area of the units must be larger and the units must be so located that heat is distributed at uniform temperature over the entire surface.

A further complication may arise out of the manner in which the units are to be installed. For example, if the choice of heating units for a platen lies between strip heaters and cartridge units, it may be found that although a larger number of cartridge units would be required to provide the same uniformity of temperature, the cost of drilling out the platen for installing cartridge units may be so much lower than the cost of machining the platen to receive strip heaters that it will more than compensate for the higher initial cost of cartridge units.

## Table II — Step-by-step Procedure in Selection and Application of Resistance Heating Units

**A. Analyze the problem**

Include all pertinent information on the machine, device, process, or material, including containers and auxiliary equipment, space available for mounting heaters, type of service, time requirements, etc.

**B. Calculate the required heater capacity**

Calculations to be on the basis of: (a) the heat necessary to bring the material to working temperature; (b) heat necessary to maintain the working temperatures. Experiments may be necessary

**C. Choose type of heater, which will best meet the purposes of the intended application**

(See Table I for physical limitations)

**D. Choose rating (watt density) which will result in reasonable life expectancy**

Use suggestions in manufacturer's catalog as guide in specific applications

**E. Select number of heaters on basis of three preceding steps**

**F. Modify the above as necessary from standpoint of economy, physical limitations, etc.**

**G. Choose sheath material**

Based on consideration of operating temperature and corrosion problem

**H. Choice of control equipment**

Thermostats for automatic temperature control; switching arrangement to reduce load factor

**I. Install units in manner to provide most rapid and efficient transfer of heat**

This includes provisions for good clamping, agitation for viscous liquids, forced convection of air, elimination of scale, etc.

# MATERIALS AND DESIGN

## *Twin Keys to Profit*

GEORGE T. TRUNDLE, JR.
*President, The Trundle Engineering Company*

WITH competition today keener than ever, many a manufacturer is finding it imperative that some method be found for reducing his production costs. He may find himself in a price situation—and therefore be thinking of ways and means which will enable him to give his customers a product just as good, at a lower price. Perhaps, in his particular picture, the competitive situation is one of quality. In that case, he will be thinking of ways and means to increase quality without raising price. He may even be striving both to improve quality and lower price. Perhaps his immediate necessity may be purely one of widening the ratio between income and outgo in order to net a more reasonable margin of the profit. No matter which one of these reasons may supply the immediate motive, the main objective is the same—that of producing a good product at a lower cost.

For some reason, which I have never been able to understand, most manufacturers, in considering the problem of reducing production costs, turn first to the labor picture. There is little margin of savings to be found in that angle today. As a matter of fact, direct labor has never represented more than a comparatively small fraction of the price of most manufactured articles. And in these days even to save a fraction of that fraction would be extremely difficult because wage scales today are not easily subject to arbitrary downward adjustments. My own opinion is that high wages are with us to stay and we may as well accept them.

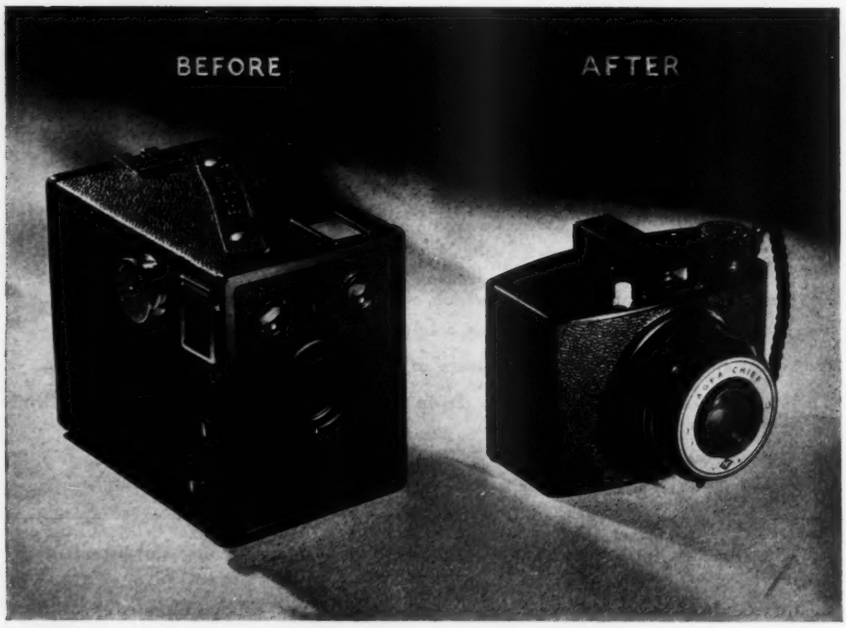
The next subject for consideration, with respect to reducing production costs, is customarily equipment. Whether there may, or may not, be such an opportunity in this field, depends upon the situation in each individual plant. In some cases replacement of obviously antiquated equipment by new equipment may, of course, help—but what about the company whose equipment is not antiquated, but who must nevertheless of necessity effect a reduction in production costs? A few corners may be cut, perhaps, in sales expense; more careful buying of material; better control of inventory.

In some companies, revision of management methods, along the line of better planning and routing in the plant and better allocation of responsibilities in the office, may work wonders. But in another company no such revision may be needed. And yet there may still be the need of cutting production costs.

We have now "made the rounds" of the subjects ordinarily considered under the subject of "cost-savings". But as yet we have not even mentioned the one field in which today there may lie more opportunities for cost reduction than in all other fields combined—the field of materials and design. Not so many years ago, a major change in the material or in the design of a product was an unusual event. It happened only as the result of a special situation or an unusual circumstance. But during recent years all this has changed, due to the remarkably rapid increase in the supply of new materials and new adaptations of old materials, and an equally rapid increase in the supply of engineering ingenuity operating in the field of product design. All of us can remember when there were only a limited number of materials available. Most of our manufactured products were made of steel, wood, leather, rubber or glass, or of limited combinations of these materials. What is the picture today?

First of all, we have at our disposal a number of absolutely new materials, chiefly in the field of plastics. Their physical properties, by comparison to older materials, are almost incredible—they are light in weight; they do not require grinding or cutting operations; they are non-conductors of electricity; they possess surfaces which are pleasing to the touch and which, therefore, do not require finishing; they have certain resistances to moisture, heat, acids, alkali, and grease; they do not corrode with time; they possess peculiar advantages with respect to physical handling and introduction into already established manufacturing processes.

Next, we have seen in recent years old materials developed into vast new ranges hitherto unknown. Take steel,




*The superiority of the new Agfa Chief camera, styled by Henry Dreyfuss is obvious. It takes the same size picture and sells in same price class as the older model*

for instance. Not so long ago steel was either tool steel or machine steel. But today "steel," as a specific material, is merely an academic term. Today we have at our command hundreds of different alloy steels, each with its own physical and chemical properties, and each capable of its own special uses and performance. Furthermore, there has been a commensurate increase in the number of shapes, sizes and forms in which various steels are available. This is particularly important today because of modern welding possibilities and because of the miracles which can be performed by modern die presses in shaping sheets and plates.

There is the same story in iron. "Cast iron" today is a general name for a wide variety of iron alloys, with an equally wide variety of performance and adaptation.

Rubber today serves a thousand and one purposes unknown to manufacturers only a few years ago. Glass now appears on the manufacturers' market as a whole range of raw materials for countless purposes. Even wood has kept pace, with new forms of pressed wood and similar processed materials unknown a decade ago.

In addition to all of these, there has been developed a great array of nonferrous materials, principally alloys of aluminum, zinc, and magnesium. And to get into other widely diversified fields, one could mention lacquers, cellophane, rayons, and many other new materials.

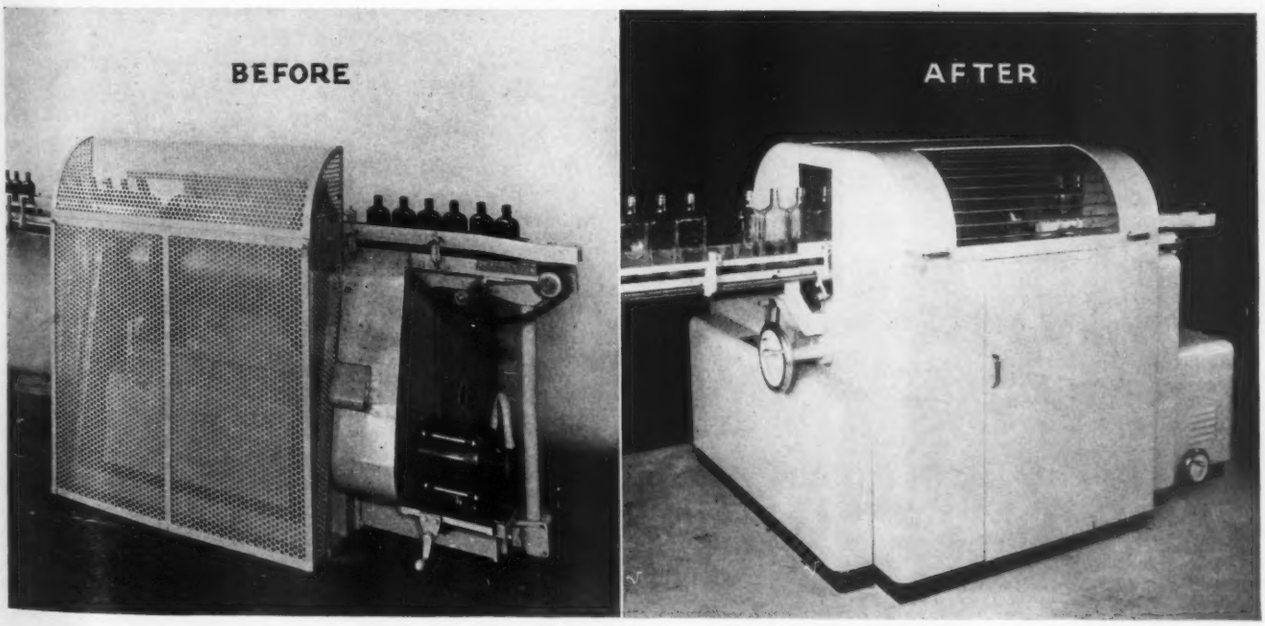
Keeping pace with developments and materials, there have been equally startling developments in methods. Consider, for instance, the progress which has been made in stamping, sand casting, die-casting, extruding, forging and molding. Every new material, or every new adaptation of an old material, has brought with it progress in methods, use and adaptation. In short, product engineering has kept pace with the development of materials.

Product engineering is purely a matter of ingenuity. A manufacturer has before him the necessity of reducing production costs. Suppose he asks the question, "To what extent can this be done by redesigning the product in the light of the materials available today?" The answer to that question is in the hands of product engineers. These product engineers may be research men for the company, executives of the company, plant superintendents, foremen, or representatives of an outside engineering organization specially equipped for that purpose. It makes no difference just who the men are. What I wish to emphasize is the fact that the men who succeed in reducing production costs by means of the redesigning of a product in the light of new materials are in fact "product engineers" and their function today, as far as cost reduction is concerned, may prove to be far more important than is apparently realized by many business executives.

Now I would not for a moment suggest to a manufacturer that any of the old line methods of endeavoring to reduce production costs should be abandoned. Of course every field should be explored; every possible step should be taken to reduce costs in direct labor, in sales, in buying and inventory control, in routing and planning of work, and in the allocation of various responsibilities in management setup. But at the same time, and at the very moment the problem arises, there should also be propounded the question, "To what extent can we accomplish our desired purpose by the redesign of product, especially in the light of new materials available today?" I am inclined to think that in a great many cases, the real answer to the problem will be found to lie in this field.

In this connection, the question of approach to the subject is important. There is always a temptation to think, "Look at this new plastic product — this new steel product — this new rubber product. They are wonderful. Can't we use them in our business?" This sort of approach does not bring the right answer. The approach which gets proper results is one which first of all defines the objective. Once the objective has been defined, it is up to product engineers to get the answer. Perhaps this can best be illustrated by a few specific examples.

A company manufacturing small motors was faced with the necessity of cutting production costs, and at the same time maintaining quality and performance. Answer — Motor frames were changed from cast iron to steel forgings. Motor bases were changed from cast iron to steel stampings. Square laminations were used instead




*When Pneumatic Scale Corporation engineers developed their new type of automatic bottle cleaner—which uses sterilized air instead of water—they created a design that has all the earmarks of quality and efficiency*

of round laminations. Result — A reduction not only in material costs but in machining and processing costs.

A company manufacturing a time-recorder sought to reduce production costs without sacrificing quality. The answer was the use of zinc alloy die castings. Because of the nature of this material, these castings can be made into such intricate shapes that one part can take the place of what formerly constituted three or four parts. Furthermore, zinc diecastings can be cast into thin sections of great uniformity. This permitted small clearances and made it possible to use every available cubic inch of space. Result — Fewer parts, more compact design, and fewer machining requirements, because of better surface qualities, substantially reduced manufacturing costs.

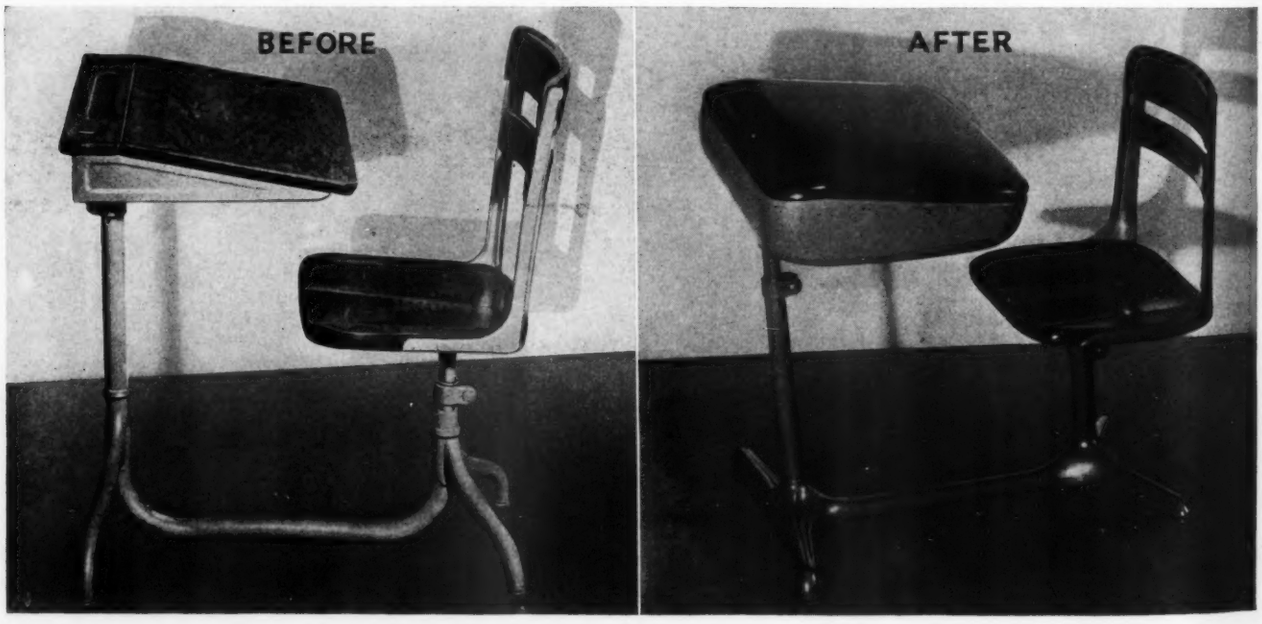
Another noteworthy achievement is the design of the new Agfa camera models, the Chief and the Pioneer. Designed for appearance by Henry Dreyfuss, these models have many new striking features. As can be seen in the illustration, the Chief is extremely compact; careful design eliminated waste space. The winding knob is plastic, light in weight compared to the metal knob in the other model. Lens mount is molded plastic, light in weight and permitting an improved design. Colored plastic shutter release is located most conveniently to control instantaneous or bulb exposure. The camera body is all-steel with grained black, water-proof paper covering as compared to the pressed chip-board construction of the older model. These new models have numerous other features not found in the older models, such as built-in synchronized flash mechanism, optical eye-level view finder, higher quality lens and shutter, and provision for a flash unit, an inexpensive accessory.

A manufacturer of a paper shredding machine sought decreased production costs while at the same time maintaining quality performance. A product engineer found a way out by redesigning the cutting knives of the machine. The knives formerly were made of solid tool steel. Now they are made of low-cost carbon steel, to which are welded small edges of an alloy cutting steel. This not only reduced the cost of production but reduced the weight of the disk which carried the knives by 50 per cent, which made possible the use of a 2 hp. driving motor instead of a 3 hp. motor. It also increased the life of the machine because the cutters can now be reground and reset.

Research proved that cleaning new bottles with sterile air is more efficient than water rinsing. Pneumatic Scale Corporation redesigned their machine to clean bottles by a blast of sterile air. As shown in the accompanying illustration, the sheet steel housing was styled for both appearance and easy cleaning. All machine adjustments are made by handwheels on the outside.

A manufacturer of motors sought to increase the ability of his motors to operate satisfactorily under extraordinarily high temperatures. The answer was found in the adoption of glass — in the form of thread, fabric, and tape — in the winding of the motor coils. The use of glass in place of conventional insulating materials made it possible not only to operate under higher temperatures but also to obtain an output of 20 hp. from a motor previously limited by frame size to an output of 15 hp. The new glass fabric possesses a high tensile strength, a resistance to deterioration at high temperatures, and high resistance to attack by moisture, oils, acids and corrosive fumes.

These are just a few out of countless illustrations which might be cited out of the current experience of industry, experience in product engineering whereby new materials and new methods utilizing new materials are put to work in order to cut costs. These are new avenues for progress which may prove productive of surprisingly immediate and substantial results. Such means constitute today, in my opinion, the most direct avenues toward cutting costs while maintaining quality, increasing quality while maintaining costs, or both cutting costs and improving quality at the same time. Certainly today every manufacturer, no matter what other ways and means may be considered for cutting costs and increasing margins, would do well to consider at the same time and as part and parcel of his regular program, research and experimentation with the aid of product engineers, to see what might be accomplished by the use of new materials and new product design — today's twin keys to profit.




*American Seating Company enlisted the aid of Designers for Industry, Inc. to create their new design of chair-desk. The greater simplicity and better appearance are obvious, while costs have been reduced by requiring fewer parts*

# TRUCK GRADE ABILITY

## *And Performance Based on Work and Power Factors*

A. C. RASMUSSEN
*Mechanical Engineer, Indianapolis, Ind.*

PRELIMINARY to any design analysis or discussion of what it is possible to do in the way of improving the road performance of trucks and tractor-trailer combinations, it is obviously necessary to understand thoroughly the many factors that are involved in the problem.

Every engineer knows that in any conversion of power to work, the amount of work output per unit of time in any system can be no greater than the power input received by that system. This fact is axiomatic. It is also well known that some power input is always absorbed in the system because of frictional obstacles in that system. Power-weight ratios and gear ratios cannot change these fundamental relations between power and work.

The measure of truck performance is the number of pounds that can be moved without acceleration over a length of highway of uniform surface and grade, generally expressed in miles, in a unit of time usually expressed in hours. The only force that the truck can exert on the highway to move itself is the tractive effort or tire pull of the rear wheels.

Tractive effort can be expressed in terms of developed engine horsepower.

$F$ = tractive effort or tire pull of rear wheels in lb.
$S$ = vehicle speed, ft. per min.
$M$ = vehicle speed, miles per hr.
$H_e$ = horsepower developed by engine
$E$ = overall efficiency from engine to rear wheels. (Generally taken at 0.90, tests show that the efficiency remains approximately constant in any gear for the entire range of road speeds used.)

$$\text{then } S = \frac{5{,}280M}{60} = 88M \qquad (1)$$

$$H_e = \frac{SF}{33{,}000E} = \frac{88MF}{33{,}000E} = \frac{MF}{375E} \qquad (2)$$

Not considering rear wheel slip nor wind resistance, tractive effort is the sum of rolling resistance $R_1$ and the grade resistance $R_2$, the latter factor is the component of the load parallel to road. In Fig. 1 let

$W$ = gross load in 1,000 lb. units of vehicle on the road
$\mu$ = coefficient of rolling resistance
$s$ = per cent grade $= \frac{a}{100}$

$$L = \sqrt{a^2 + 100^2} = 100\sqrt{\left(\frac{a}{100}\right)^2 + 1}$$

$$= 100\sqrt{s^2 + 1}$$

$$R_2 = \text{grade resistance} = \frac{(1{,}000W)a}{L}$$

$$= \frac{(1{,}000W)a}{100\sqrt{s^2 + 1}} = \frac{(1{,}000W)s}{\sqrt{s^2 + 1}}$$

$$K = \frac{1{,}000W \times 100}{L} = \frac{1{,}000W \times 100}{100\sqrt{s^2 + 1}}$$

$$= \frac{1{,}000W}{\sqrt{s^2 + 1}}$$

$$R_1 = \text{rolling resistance} = K\mu$$

$$= \frac{1{,}000W\mu}{\sqrt{s^2 + 1}}$$

Since the value of the term $\sqrt{s^2 + 1}$ is very close to unity, the term is often omitted. When this term is omitted

$$R_2 = (1{,}000W)a$$
$$R_1 = (1{,}000W)\mu$$

then

$$F = (R_1 + R_2)$$
$$= \mu(1{,}000W) + s(1{,}000W) \qquad (3)$$
$$= (\mu + s)\,(1{,}000W) \qquad (4)$$

substituting this value of $F$ in Equation (2)

$$H_e = \frac{WM(\mu + s)}{0.375E} \qquad (5)$$

For a value of $E$ equal to 0.90

$$H_e = 2.963WM(\mu + s)$$

In Table I are listed values of $\mu$ for different types of roads.

The resistance which the vehicle meets in pushing through the air varies considerably with driving conditions. As a consequence, average values have generally been assumed for calculating wind resistance. A common formula for estimating wind pressure, in which

$p$ = wind pressure per sq.ft. of frontal area

is

$$p = 0.004M^2$$

with

$A$ = frontal area in sq.ft.
$R_3$ = total wind resistance in lb.
$R_3 = pA = 0.004M^2A$

Including the effect of wind resistance

$$F = (R_1 + R_2 + R_3)$$

and Equation (2) becomes

$$H_e = \frac{M(R_1 + R_2)}{375E} + \frac{MR^3}{375E}$$

$$= \frac{WM(\mu + s)}{0.375E} + \frac{0.004M^3A}{375E}$$

$$= \frac{WM(\mu + s)}{0.375E} + \frac{M^3A}{93{,}750E} \qquad (6)$$

In considering the subject of the

**Table I—Coefficients of Rolling Resistance for Various Roads**

| Type of Road | $\mu$ |
|---|---|
| New and smooth concrete, brick and asphalt | 0.012 |
| Good macadam | 0.018 |
| Rough hard road | 0.025 |
| Hard gravel | 0.032 |
| Poor macadam, poor gravel and dirt | 0.060 |
| Firm moist sand | 0.160 to 0.250 |

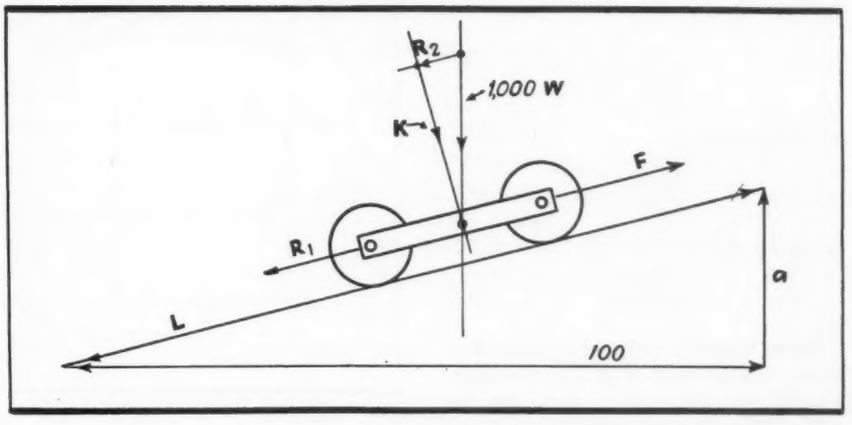



*Fig. 1—Forces acting on a truck ascending a grade and method of designating grade*

function of gears in the trains between the engine and the rear wheels, perhaps attention should be called to a fact that is sometimes lost sight of when discussing truck performance. Gears can accomplish but one result. They are simply the mechanism through which a mechanical advantage is obtained by reducing the speed of the driving unit, and are a means only for increasing torque through a reduction in speed. Gears cannot in themselves generate or increase power. The calculations involved in determining overall gear ratios are simple and well known; with

$g_e$ = final drive ratio
$g_a$ = drive axle ratio
$g_x$ = transmission ratio in any step
$G$ = overall gear ratio

$$\text{then } G = g_e \times g_a \times g_x \qquad (7)$$

The tractive effort $F$ in terms of engine torque and overall gear ratio also can be readily computed if brake dragging, and windage of clutch, shaft brakes, universals, brake drums and wheels are all neglected.

$Q$ = torque of engine, lb. in.
$r$ = loaded radius of tire, in.

$$\text{then } F = QGE/r \qquad (8)$$

A ratio which often appears in expressions relating to the performance of trucks is the tractive factor, here designated as $T_f$. The ratio is the tractive effort in lb. per lb. of gross load, or

$$T_f = F/(1{,}000W) \qquad (9)$$

In order to haul loads up grades and to accelerate from stand-stills, it naturally follows that trucks must have some excess tractive ability over and above that required to maintain given governor-throttle controlled speeds in high gear on level roads, therefore, it is reasonable to measure performance ability of a vehicle by the grade that can be negotiated.

The per cent grade that can be negotiated can be derived from Equation (3) as

$$s = \frac{F}{(1{,}000W)} - \mu \qquad (10)$$

$$= T_f - \mu \qquad (11)$$

From Equation (2)

$$F = \frac{375EH_e}{M}$$

Substituting this value of $F$ in Equation (10)

$$s = \frac{375EH_e}{1{,}000WM} - \mu \qquad (12)$$

From Equation (12) an equation can be derived in terms of the gross vehicle weight per horsepower that can be pulled up a grade at various speeds, expressed as

$$\frac{1{,}000W}{H_e} = \frac{337.5}{M(s + \mu)} \qquad (13)$$

The curves in Fig. 2 are plotted from Equation (13) with a coefficient of rolling resistance taken as 0.025 for rough hard roads, for various grades, and an overall efficiency of 0.90 from engine to rear wheels.

When calculating vehicle road speeds a factor is often used which expresses the road speed of a vehicle in mi. per hr. for 1 r.p.m. of the driving tire, let $Z$ denote this factor then

$$Z = \frac{2\pi r \times 60}{12 \times 5{,}280} = \frac{r}{168} \qquad (14)$$

For truck and bus tires
$r$ = 0.49 of nominal O.D. of tire approx.

Nominal O.D. of tire = wheel dia. + 2 × nominal tire dia., and

$$Z = \frac{0.49 \text{ Nom. O.D.}}{168} = \frac{\text{Nom. O.D.}}{343}, \quad \text{approx.} \qquad (15)$$

Let
$N$ = r.p.m. of engine
$N_e$ = r.p.m. of driving tire
$M = ZN_e = Z(N/G)$

$$= \frac{Nr}{168G} = \frac{N \times \text{Nom. O.D.}}{343G}, \quad \text{approx.} \qquad (16)$$

Except where stated the equations do not include the effects of wind resistance. Also, the equations have been developed on the basis that the engine can develop its maximum horsepower at the speeds under consideration.

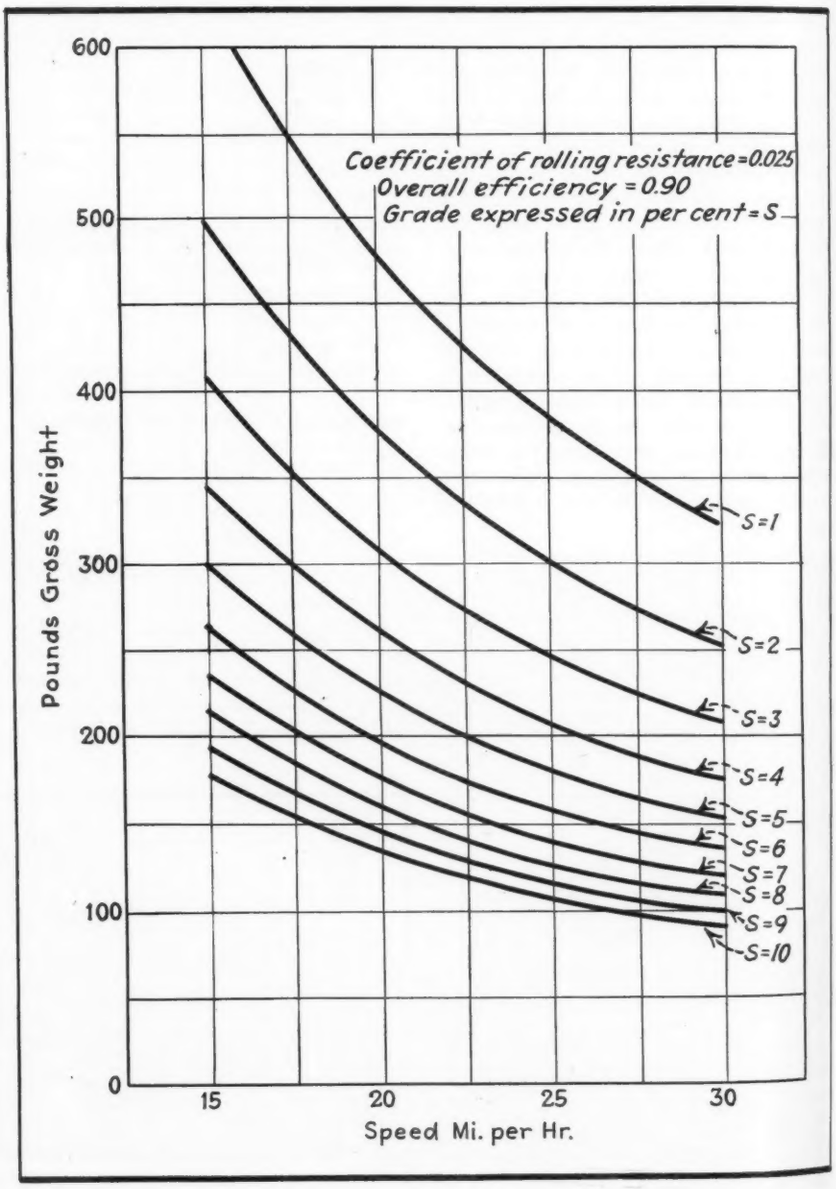



*Fig. 2—Gross vehicle weights that can be pulled up-grade at various speeds by one horsepower delivered by engine*

# METAL SURFACE CLEANERS

THE articles on product finishing which have appeared in the April, May and June numbers of PRODUCT ENGINEERING, pages 163-4, 217-19 and 269-70, were principally concerned with recommendations on the proper choice of solvent and with common finish troubles, their causes and remedies. More basic, however, than many remedies is proper cleaning and treatment of the surface before the actual finishing operation. Degreasing can be done by alkaline, solvent cleaning processes or chemical cleaning. This table lists the tradenames and methods of application of commercial cleaning preparations generally recommended for surface cleaning of aluminum and its alloys, bronze and copper, lead and tin plate, steel and iron, zinc, cadmium and chrome-plate and galvanized parts.

### I. Aluminum and Aluminum Alloy

1. **Rough cast aluminum (degrease and etch)**
   Metalprep #10 diluted with 3 parts water (wipe off)
   Deoxidine #126 diluted with 3 or 4 parts water (wash)
   Preesol #12 diluted with 3 parts water (wipe off)

2. **Polished aluminum surfaces (etch and degrease)**
   Metalprep #11 and #33 diluted with 3 parts water
   Deoxidine #126 diluted with 3 or 4 parts water
   Preesol #12 diluted with 3 parts water

### II. Bronze and Copper

1. **Rough castings (degrease and etch)**
   Metalprep #25 diluted with 3 parts water
   Deoxidine #126 diluted with 3 or 4 parts water

2. **Polished surfaces (degrease and etch)**
   Metalprep #45 diluted with 3 parts water
   Deoxidine #126 diluted with 3 or 4 parts water (wash)
   (Follow Metalprep with an alcohol rinse)

### III. Lead, Terne Plate and Tin Plate

1. **Light grease**
   Metalprep #25 diluted with 3 parts water (wipe off)
   Deoxidine #126 diluted with 3 or 4 parts water (wash)

2. **Heavy grease**
   Metalprep #45 diluted with 3 parts water (wipe off)
   Deoxidine #126 diluted with 3 or 4 parts water (wash)
   (Follow Metalprep with petroleum hydrocarbon thinner rinse)

### IV. Steel and Iron

1. **Horizontal surfaces (Deep Rust)**
   Metalprep #25 or #45 diluted with 3 parts water (wipe)
   Deoxidine #126 diluted with 3 parts water (wash off)
   Sol-Klean #1205 diluted with 2 parts water (dry 24 hours)
   Rust-i-cide #75 diluted with 1 or 2 parts water (wipe)

2. **Vertical surfaces**
   Metalprep #106 or #107 (wash off)
   Deoxidine #202 (dust off when dry)
   ACP Rust Proofer 33 (wash off)
   Sol-Klean #1205 (24 hour dry)

3. **Light to moderate surface rust and scale**
   Metalprep #10, #11, or #33 diluted with 3 parts water (wipe off).
   Preesol #12 diluted with 3 parts water (wipe off)
   Sol-Klean #1205 diluted with 3 parts water (dry 24 hours)
   Rust-i-cide #75 diluted with 1 or 2 parts water (wipe)
   ACP Rust Proofer 33 full strength (wash off)

### V. Zinc, Cadmium or Chromium Plated Steel and Zinc Base Die Castings

1. **Hand application**
   Metalprep #10 or #11 diluted with 2 or 3 parts water (wipe off)
   Lithoform #2, undiluted, brushed or sprayed (wash)

2. **Dip application**
   Metalprep #45 diluted with 2 parts water (wipe off)
   Lithoform #31 or #32 diluted with 3 parts water, heated to 150 deg. F., dipped and washed off

### VI. Galvanized or Galvannealed Surfaces

Metalprep #10 or #11 diluted with 2 or 3 parts water (wash off)
Lithoform #2 undiluted, brushed or sprayed (wash off)
Metalprep unless otherwise specified is brushed
Galvaprep diluted with 3 parts water (wash off after 30 seconds)

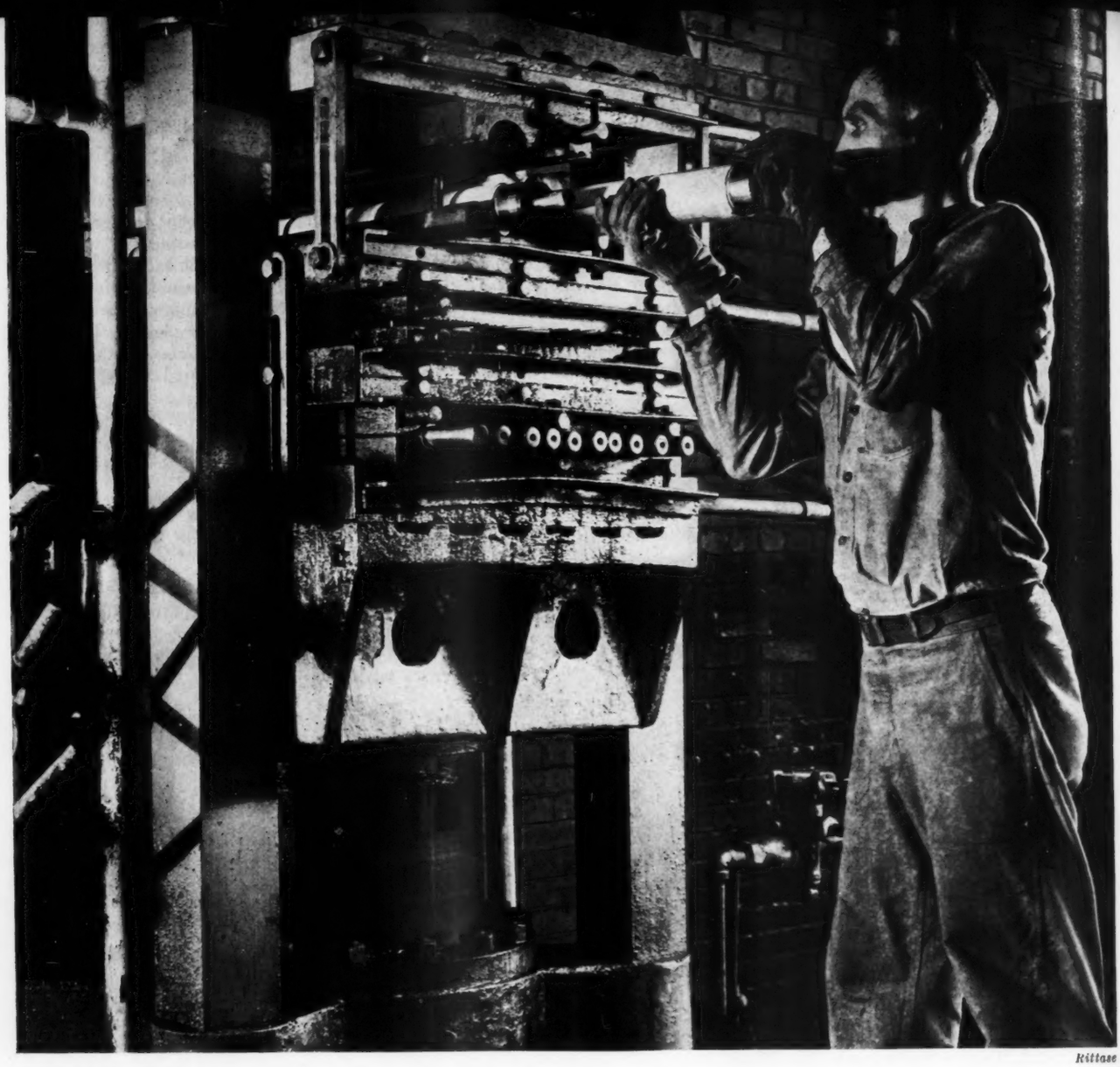
### Index of Manufacturers

Neilson Chemical Company, Detroit, Mich.
*Metalprep*
*Galvaprep*

American Chemical Paint Company, Ambler, Pa.
*Deoxidine*
*Preesol*
*ACP 33 Rust Proofer*
*Lithoform*

Rusticide Products Company, Cleveland, Ohio
*Rust-i-cide*

Industrial Chemical Products Company, Detroit, Mich.
*Sol-Klean*



Rittase

# LAMINATED PHENOLIC

## *Considerations Governing Choice of Type*

S. W. PLACE
*Chief Engineer, Synthane Corporation*

PROPERTIES of laminated phenolic resin materials are primarily dependent on type of filler material, the phenolic resin which serves principally as the binder, and the time and temperature of cure. The filler material may be cotton fabric, paper, asbestos or glass fabric. The laminated phenolic with a fabric or paper base may be combined with natural rubber or synthetic rubber-like materials such as Thiokol, Neoprene, or Corprene. The resin may be impregnated with other material, such as graphite in order to obtain certain desired properties, or the impregnated filler sheet may be partially cured, macerated and molded to shape.

Of the two most common types of laminated phenolic, the fabric-base grade is usually suitable where good mechanical properties such as impact strength or resistance to shock are required, and where electrical requirements are of secondary importance. The paper-base grades are suitable for applications where electrical properties are important considerations and where mechanical properties such as strength and impact resistance are secondary.

In addition to these two general grades of paper- and of fabric-laminated, the resin may be laminated with asbestos-paper base or asbestos-fabric base for particular applications in which strong alkaline conditions are encountered, or for exposure to chemical

salts in high concentration. A comparatively recent development, woven-glass-cloth laminated, has excellent resistance to strong concentrated acids including chromic and strong sulphuric acids.

Combination materials utilize rubber, Neoprene, Corprene, Thiokol or vulcanized fibre, thus combining physical properties such as the resilience of rubber and Corprene, the oil-resisting ability of Neoprene and Thiokol and the arc-resisting or arc-damping quality of vulcanized fibre with the machinability and strength of the laminated phenolic.

In graphite-impregnated laminated, the graphite acts as a lubricant, thereby reducing the coefficient of friction and minimizing temperature rise and frictional power losses. Other special materials include molded laminated and molded macerated grades. In the molded laminated types, pieces of impregnated paper or fabric are cut to the required dimensions to fit a mold, and are then cured under heat and pressure. In molded macerated materials, impregnated paper or fabric is shredded to small pieces which are then cured in a mold under heat and pressure. Either of these methods may show considerable cost savings over machining methods if sufficient quantities are involved to warrant the expense of molds. However, molded macerated materials are generally somewhat weaker mechanically than the corresponding laminated sheet.

The nomenclature of the various types commercially available has been standardized by *N.E.M.A.* and descriptions of their inherent characteristics are included in the *N.E.M.A. Standards.*

There are three general classes of paper base stock, grades *X*, *XX* and *XXX*. On the punching stock grades the letter *P* follows the grade classification. These grades have suitable plasticizers added to the impregnating resin which soften the sheet and make good punching possible. Of course it is possible to punch the non-plasticized paper base grades by preheating the material in some cases. Moisture resistance, dimensional stability and good electrical properties increase with the number of *X*'s.

For mechanical applications where good electrical properties are of secondary importance, grade *X* is recommended. However, if good electrical properties are required even under conditions of high humidity and where high mechanical and impact strength is of secondary importance then grades *XX* and *XXX* are recommended.

For high-impact applications and particularly where electrical considerations do not prevail, fabric-base laminated is recommended. These grades are known as *C*, *CE*, *L*, and *LE*. The laminations in the *C* grades are heavy-weave fabrics, 6 to 16 oz. per sq. yd. as a base; the *L* grades have fine-weave fabrics, 3 to 4 oz. per sq. yd. as a base. The finer-weave cloths show practically as good mechanical strength as the heavier weaves except that impact strength is somewhat lower. The fine weave cloth, although somewhat higher in price, is preferred in applications where a fine machined appearance and clean cuts are desirable, as in fine tooth gears or breaker arms. For better electrical properties where impact is a factor, grades *CE* and *LE* are recommended in preference to paper-base laminated; these are identical to the *C* and *L* grades, except that the impregnated fabric has been further processed to improve electrical qualities of the finished sheet. However, they have generally poor impact strength and a slightly lower tensile and transverse strength than the corresponding *C* and *L* grades.

Where heat resistance and resistance to moisture absorption is a factor, asbestos base laminated, grade *A* or *AA*, may be used. These materials are more resistant to flame and slightly more resistant to heat than other laminated grades because of high inorganic content. Where these same qualities are desired but more mechanical strength is necessary, grade *AA* can be used, this is an asbestos-fabric base laminated material. Electrical properties of these two grades are poor and machining is difficult. However, both have good moisture resistance and dimensional stability under high humidity conditions. Immersion in water for a period of six months to a year has shown a water absorption of not more than 3 to 5 per cent.

The safe operating temperature of laminated bakelite depends upon the selection and whether the material is to be subjected intermittently or continuously to the specified temperature. Generally speaking, 225 deg. F. is the maximum safe continuous operating temperature for any of the usual grades; 250 deg. F. is the limit for intermittent application. The asbestos-base grades may be used at somewhat higher temperature, and by special processing during manufacture, this material will withstand intermittent temperatures up to 400 deg. F.

For structural members, or electrical insulating parts under dielectric stress, a factor of safety of four is recommended for mechanical strength and six for dielectric strength.

Laminated bakelite machines at much the same cutting speeds as does brass. As a general rule, the use of cutting oils is not recommended except for fine thread cutting. Detailed information regarding procedure for various machining operations is available from any laminator. See also publication No. 39-58, dated November, 1939, and issued by the National Electrical Manufacturers' Association.

The combination of laminated phenolic and rubber, bonded together under heat and pressure, is an interesting application in the uniting of two different materials having different characteristics. Rubber is naturally resilient, whereas the laminated plastic is tough and strong and has good impact strength. Paper or fabric-base plastic may be laminated with rubber from 1/64 in. up to ½ in or more in thickness. Combinations are: rubber one side; rubber both sides; plastic both sides, rubber between; alternate layers.

Rubber generally used is equivalent

## Comparative Properties of Glass-Fabric Laminated and Grade *CE* Fabric Laminated

**(Specimens ⅛ in. thick)**

| Properties | Glass Base | Grade *CE* |
|---|---|---|
| Dielectric Strength (short time test) | 396 V.P.M. | 325 V.P.M. |
| Power Factor at 1,000,000 Cycles | 0.011 | 0.055 |
| Dielect. Const. at 1,000,000 Cycles | 4.4 | 5.5 |
| Loss Factor at 1,000,000 Cycles | 0.048 | 0.30 |
| Power Factor at 1,000,000 Cycles after 24 hr. in water | 0.10 | 0.075 |
| Tensile Strength (depends on fabric) | 6000–15000 lb. per sq. in. | 8000–11000 lb. per sq. in. |
| Transverse Strength (depends on fabric) | 15000–25000 lb. per sq. in. | 17000–22000 lb. per sq. in. |
| Compressive Strength | 49000 lb. per sq. in. | 36,000 lb. per sq. in. |
| Izod Impact Strength | 10 ft. lb./in. of notch | 6.7 ft. lb./in. |
| Cold-flow (after stabilized) | 0.20 per cent | 0.5–1.0 per cent |
| 24 hr. water absorption | 1.2–2.3 per cent | 0.50–1.2 per cent |
| Specific Gravity | 1.55–1.60 | 1.35 |
| Rockwell Hardness | 110–115 | 105–110 |
| Surface leakage resistance after 7 days at 90–95 per cent Humidity | 5 megohms | 100 megohms |

to "packing rubber," containing 6/10th of 1 per cent free sulphur. Where oil-resistance is important, special rubber or synthetic rubber can be used. In a typical application, electrolytic and oil type condensers, the combination washers have rubber on one side and laminated plastic on the other. The plastic supplies mechanical strength and protects the rubber from corrosive action of the chemicals. In another, a round headed machine screw with a cork washer passes through a hole in the wall from the inside. A rubber-plastic washer then goes on from the outside with the rubber next to the wall. The laminated plastic on the outside offers a firm base for seating the nut.

Glass-fabric-base material has been available for the past year. It is primarily suitable for certain mechanical and chemical applications. Electrical properties are not stable; it is not recommended where excellent electrical properties are required, although it may be used in cases where requirements are not severe.

While mechanical strength is 10-20 per cent better than that of cotton-fabric-base material, this is hardly enough to warrant the additional cost except for special applications. There is, however, a 50 per cent improvement in impact strength and considerable improvement in resistance to cold flow.

Probably the largest present use for this glass-base material is in chemical applications since glass is practically immune to attack by most acids except hydrofluoric acid. This is not generally true of cellulose-base materials. Glass-base is not recommended for any applications involving alkali-base materials as glass is attacked by most alkalies.

Disks of graphitized laminated material under test were held in a lathe and a steel disk was then pressed against the surface of test materials with a uniform load of 20 lb. at 525 r.p.m. and with a uniform load of 80 lb. at speed of 154 r.p.m. Differential increase in the watts consumed is listed below for the different grades under two different conditions. The watts representing the power consumption are a guide to the improvement to be obtained with grade *C-YB*, since the power consumed is proportional to frictional load and indicates two things: the wear likely to be experienced, and the amount of heat generated by the friction.

General rules cannot be made for performance of standard types when exposed to various chemicals, since individual conditions vary widely. Impurities or associated materials, in themselves harmless to synthetic resins, very often cause a breakdown which otherwise might not occur. A good example of this is carbon tetrachloride, which alone is a good, stable solvent for many organic substances. This is not so when solutions of certain organic materials in carbon tetrachloride are exposed to a low heat of 120 deg. F., oxygen of the air, moisture as low as 1/10 of 1 per cent, and metals such as iron or zinc from the container. Under these conditions the mixtures of carbon tetrachloride and various metallic chlorides are corrosive and attack resins.

## Test Results On Graphitized Laminated

**(Watts consumed when steel disk was pressed against rotating specimen disk held in lathe)**

| Grade | Uniform Load on Steel Disk | |
|---|---|---|
| | 20 lb. at 525 r.p.m. | 80 lb. at 154 r.p.m. |
| Grade *C-YB* | 145 watts | 95 watts |
| Grade *L* | 185 watts | 130 watts |
| Grade *C* | 185 watts | 135 watts |
| Grade *A* | 185 watts | 120 watts |
| Grade *AA* | 205 watts | 105 watts |
| Grade *XX* Black | 235 watts | 160 watts |
| Grade *XX* Natural | 265 watts | 135 watts |

In view of the above it is difficult to generalize, but in the selection of a laminated sheet for a chemical application the choice of the base fabric or paper is most important, as it is usual that the chemical will first destroy the base. Cellulose paper should be avoided in all cases as the structure of paper is inherently poor for good impregnation. Also, water absorption is comparatively high, and is directly proportional to the chemical resistance.

Cellulose cloth should be selected for uses where weak acids, weak bases and solutions of various salts are encountered, and generally speaking has better resistance than the other two base materials which are higher in price.

Asbestos should be used only when strong alkaline conditions are encountered or when exposed to salts in high concentration which tend to hydrolyze or split to alkaline radicals. Asbestos, being alkaline, is easily attacked by acids and salts.

Glass-base is easily attacked by alkalies in all concentrations, but is the most resistant material against acids. Even chromic acid and strong sulfuric have little effect on glass laminated.

## Laminated Phenolic Paper Base Tubing— Standard Properties

**(Tests made on 1x1⅛ in. tubing. Based on N.E.M.A. Standards)**

| | Grade *X* Rolled | Grade *XX* Rolled | Grade *X* Molded | Grade *XX* Molded |
|---|---|---|---|---|
| | Minimum Standards | | | |
| Density grams per cc | 1.10 | 1.10 | 1.25 | 1.25 |
| Tensile Strength lb. per sq. in | 7,500 | 7,000 | 9,000 | 7,500 |
| Compressive Strength axial lb. per sq. in | 10,000 | 12,000 | 15,000 | 15,000 |
| Dielectric Strength volts per mil short time | 500* | 400 | 400 | 300 |
| Dielectric Strength volts per mil step by step | 300 | 250 | 250 | 200 |
| | Maximum Standards | | | |
| Water Absorption percentage by weight 1 in. length — 24 hr at 25° C. ± 2° C. | 5.0 | 2.5 | 4.0 | 2.0 |
| As Received Condition power factor | 0.040 | 0.040 | 0.045 | 0.040 |
| As Received Condition dielectric constant | 5.0 | 5.0 | 6.0 | 5.5 |
| As Received Condition dielectric loss factor (at $10^6$ cycles) | 0.20 | 0.20 | 0.26 | 0.22 |
| After 24 hr. immersion in water at 25 C. power factor | 0.070 | 0.055 | 0.070 | 0.055 |
| After 24 hr. immersion in water at 25 C. dielectric constant | 6.0 | 6.0 | 7.5 | 6.5 |
| After 24 hr. immersion in water at 25 C. dielectric loss factor (at $10^6$ cycles) | 0.42 | 0.33 | 0.52 | 0.35 |

* Note.— The high dielectric strength of Grade *X* rolled tubing is only true under dry conditions. Under high humidity its dielectric strength is low.

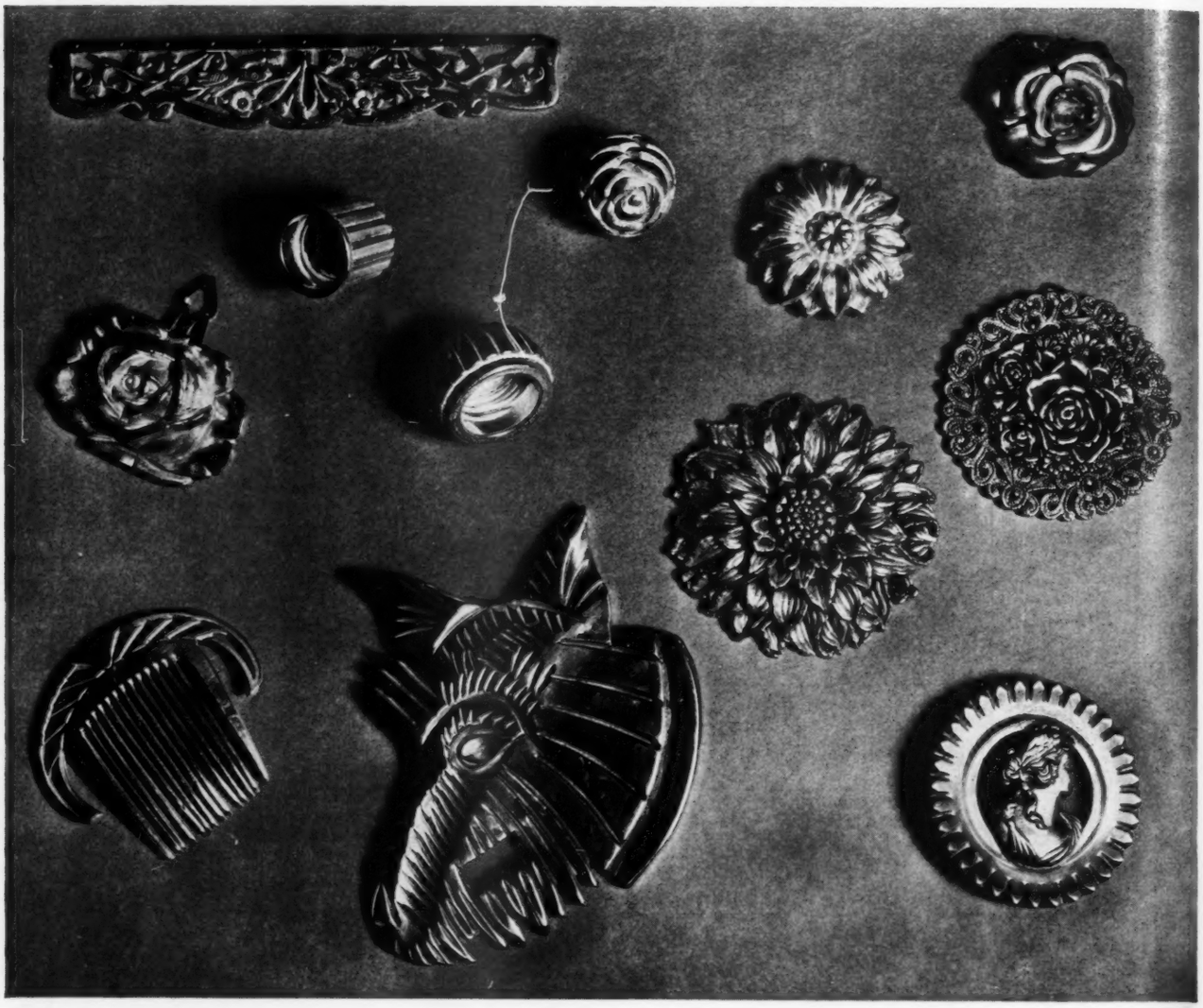
## Laminated Phenolic Plate — Average Standard Properties

*Based on Standard A.S.T.M. Tests*

| Grade | Base | Average Standard Physical Strength (lb. per sq. in.) for specimens $\frac{1}{16}$ to 1 in. thick | | | Average Standard Dielectric Losses at $10^6$ Cycles thicknesses up to 1 in. | | | Average Standard Dielectric Strength † (volts per mil) thickness $\frac{1}{16}$ in. | | Average Standard Water Absorption † sample $3 \times 1 \times \frac{1}{16}$ in. at 25° C. | Application |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Tensile | Flexural | Compressive (flatwise) | Power Factor | Dielectric Constant | Dielectric Loss Factor | Short Time | Step by Step | Percentage by Weight | |
| *X* | Paper | 12,500 | 21,000 | 35,000 | 0.06 | 5.5 | 0.32 | 700 | 500 | 4.0 | Where best electrical properties are required, such as for radio condenser stator brackets and parts carrying high frequency currents that require a material with a low dielectric loss, high insulation resistance and a low affinity for moisture as well, so that electrical qualities will not be affected by long exposure to high humidities. Where cold flow is highly important special grades in the *XX* or *XXX* classification are available. Where electrical requirements are not severe and where speed of fabrication is important, grade *XP* should be used. Lettering or markings on panels is done either by engraving or by a method of printing applicable at a low cost in sizeable quantities. |
| *P* | Paper | 8,000 | 15,000 | 22,000 | 0.06 | 5.5 | 0.32 | 700 | 500 | 3.0 | |
| *XX* | Paper | 8,000 | 16,000 | 34,000 | 0.040 | 5.0 | 0.20 | 700 | 500 | 1.3 | |
| *XXP* | Paper | 8,000 | 16,000 | 25,000 | 0.040 | 5.0 | 0.20 | 700 | 500 | 1.3 | |
| *XXX* | Paper | 7,000 | 15,000 | 32,000 | 0.032 | 4.8 | 0.15 | 650 | 450 | 1.0 | |
| *XXP* | Paper | 7,000 | 15,000 | 25,000 | 0.027 | 4.5 | 0.12 | 650 | 450 | 1.0 | |
| *C* | Fabric | 9,500 | 20,000 | 38,000 | 0.10 | 7.0 | 0.70 | 200 | 120 | 3.0 | Fabric-base laminated possess mechanical qualities of high tensile, transverse, compressive and impact strength together with toughness, resilience, low coefficient of expansion, low thermal conductivity and ease of machining. For instance, light weight and oil-resistance makes it a good choice for ball-bearing retainers. Resilience impact strength and wearing qualities plus high tensile, transverse and compressive strengths also make fabric-laminated useful in such applications as gears and pulleys, cams, bearings, bushings, piston rings and valve disks. For airplane applications, fabric-laminated is usually specified for cable pulleys, cable fair-leads, bearing spools and shims for engine mounts. |
| *CE* | Fabric | 8,000 | 17,000 | 36,000 | 0.055 | 5.5 | 0.30 | 500 | 300 | 1.5 | |
| *L* | Fabric | 9,000 | 20,000 | 35,000 | 0.10 | 7.0 | 0.70 | 200 | 120 | 2.0 | |
| *LE* | Fabric | 8,500 | 19,000 | 37,000 | 0.045 | 5.0 | 0.22 | 500 | 300 | 1.2 | |
| *A* | Asbestos Paper | 8,000 | 16,000 | 36,000 | None | None | None | 225 | 135 | 1.25 | Have much the same properties as the corresponding paper-base and fabric-base type respectively, except that electrical properties are rather poor and machining is difficult. Asbestos-base grades, notably *AA*, have good moisture resistance and dimensional stability under high humidity. |
| *AA* | Asbestos Fabric | 10,000 | 20,000 | 38,000 | None | None | None | *50 | *30 | 1.5 | |

* ⅛″ thickness.

† Dielectric strength and water absorption values vary greatly with thickness. For other thicknesses than $\frac{1}{16}$ in. consult standards for individual grades.



*Molded plastic parts having intricate detail and deep undercuts electroplated to simulate metal*

# METAL PLATED PLASTICS

JOSEPH B. KUSHNER
*Metal Finishing Consultant*

COMBINING metals and plastics by electro-deposition offers to the product engineer an interesting and novel means of taking advantage of the properties of both materials. Plating on non-conductors is an old story. Materials such as plaster, wood and wax were metal plated almost a hundred years ago, when the art founded by Faraday was in its infancy. Recent developments, however, have improved the process so that it now offers the designer of molded plastics a new range of effects and applications.

Plating on plastics can be effectively employed in design to obtain: light weight with the appearance of metal; decorative effects; surface hardness for plastic surfaces subject to wear; reduced moisture absorption; heat resistance; and electrostatic shielding.

One early method for plating on non-conductors which to some extent is still practiced today, consists of four essential steps. The object to be plated is given one or more coats of varnish, depending on its porosity. When the varnish is "tacky" or almost dry a conducting powder of either finely divided copper, bronze or graphite, is brushed or sprayed on the work. After the varnish has dried, electrical contact is made with the metal powder film by means of copper wire. The work is plated in a special acid copper bath to prevent chemical attack of the film before a layer of metal has been deposited, after which it is transferred to a regular acid copper bath, given a four to eight hour deposit of copper, removed, and scratch brushed or polished and finished as desired.

There are many practical difficulties with this method. Each piece requires many hand operations involving no

little skill and a great deal of time. The powder film is often non-uniform in conductivity, resulting in uneven and slow plating. Frequently the metal film is non-adherent or gradually pulls away from the base with the formation of blisters and bubbles. Where the deposit is adherent, there is a tendency for roughness or "orange peel" to develop because of the clumping of the metallic particles. This roughness is accentuated and magnified by subsequent deposition of metal.

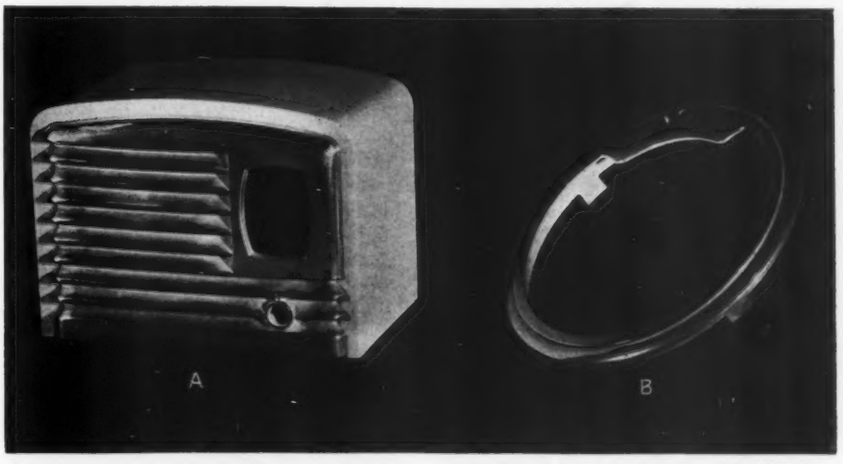
### *Plating Procedure*

The new method for depositing metal on non-conductors which is particularly applicable to plating on plastics, eliminates all these difficulties and faults. The method is based on the chemical reduction of silver bearing compounds, resembling somewhat the modern technique for making mirrors. However, if one tries the ordinary mirror making solutions for this purpose, he will meet with little success. Only certain proprietary solutions and devices especially designed for plating plastic materials seem to be able to do the trick. In the cycle of operations under the new method the work is thoroughly cleaned, then placed in a tank or barrel for treatment with two special solutions which produce a bonding metallic coat of silver, of almost molecular thickness. Where the work is too large to be handled in tank or barrel it can be sprayed. After rinsing, the work can be immediately plated. If the work is small it is plated in a barrel, or if the work is large it is plated on a rack, with ordinary copper or silver plating solutions. The plated surface, unlike that produced by powder, is uniformly conductive and will receive an immediate electro-deposit.

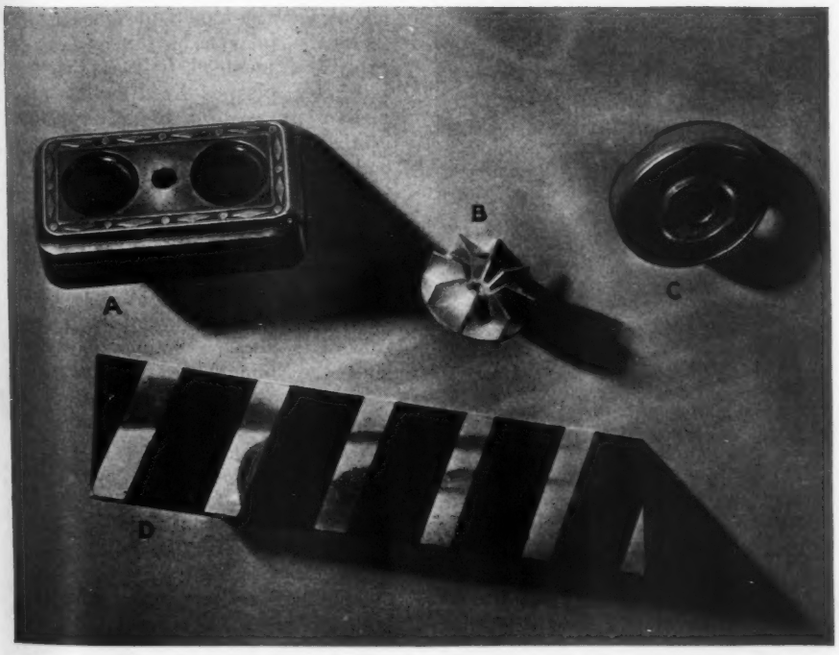
Little care need be taken in making electrical contact in contrast to that required with the powder method. Deposits up to 0.01 in. thick can be plated, though for most work 0.0001 in. thickness is satisfactory. Any metal can be plated on the prepared plastic part, the usual choice being copper, silver, nickel, gold, rhodium, chromium and cadmium or combinations of these metals. After the parts have been plated, they can be further treated by polishing, brushing, tumbling and/or oxidizing and coloring.

Because the initial bonding coat of silver actually penetrates the surface pores of the plastic material and is of molecular dimensions, perfect adhesion is obtained resulting from a combination of anchorage and atomic attraction, with an exact reproduction of the plastic surface. No roughness or "orange peel" develops because the silver film is perfectly smooth, its smoothness being a replica of the plastic surface beneath it. Also important is the fact that the method can be employed on a production scale by the use of barrels and racks with a minimum of skilled labor required.

Since very little silver is used in the bonding coat, the cost of the process is low as compared to other methods of combining metal and plastic by surface or mold treatment. The plastic can be molded in one piece then plated so that all or part of the surface is covered in a fixed or prearranged design, with any metal desired. The increased size of the plated plastic object is of no consequence as the thickness of the plated metal is much less than the dimensional tolerances permitted in the molding of plastic parts or pieces.




*(A) Molded housing for radio set in which the louvred grille panel is gold plated to enhance appearance. (B) Automobile ceiling light dome ring of plastic material gold plated on outer surface*




*Group of plastic parts electroplated by new method. (A) Housing for receptacle outlet unit. (B) Impeller for toy whistle. (C) Housing for camera lens and shutter. (D) Variable electrical resistor contact strip*

Surprising as it seems these deposits can be buffed and tumbled without any ill effect. It would normally be expected that blistering or lifting off from the surface would occur because of the difference between the expansion coefficients but the heat generated by a polishing operation is rapidly conducted and radiated away by the metal film before the heat has an opportunity to penetrate to the plastic beneath.

Parts molded from any of the plastic

materials can be plated with the new process. The physical properties of the plastic material used remain unchanged after plating. The metallic plated surface, however, is an electrical conductor but this property resides only in the metal coating. The non-resonant properties of plastics are not affected by the electro-deposited metal coatings.

There are a number of possible industrial applications for plating on plastics. Some of these have already been adopted, others await the consideration and further study by the design and product engineer before adoption.

### *Possible Applications*

Plating on plastics makes possible many interesting and beautiful effects in metal-plastic design. A large radio concern is having its molded phenolic resin radio cabinets finished with a metal electroplate on the escutcheon and speaker grille. The metal deposited is copper, this is later oxidized to an antique bronze to produce a beautiful contrast with the light walnut covered plastic case.

Handles made of plastics can be effectively plated to simulate inlaid metal. They also can be covered all over with a hard wearing metal such as chromium. The cost for simulating certain types of metal inlay is materially less than what it would be to actually inlay the plastic because no second set of dies is needed.

One property of plastic materials is low surface hardness. This prevents plastics being used in applications where otherwise the strength and lightness inherent in plastics would be ideal. In applications where high surface hardness is required plastics are short lived. A typical application is that of roller guides and cams. However, roller guides can be advantageously made of plastics if they are plated with a hard anti-wear surface such as chromium. The light weight and sound insulating properties of the plastic impart almost inertialess and noiseless motion and the chromium plate a durable hard wearing surface. This principle is already being employed by several machine manufacturers.

Gears and bearings offer other possibilities for the application of plating on plastics. Plastic gears are constructed for most part of the laminated phenolic resins because of their superior wearing qualities. These are relatively expensive. There is no reason why gears cannot be made of cheaper plastic materials and plated on the wearing surfaces with chromium or hard nickel. One concern is at the present time experimenting with the possibility of using electro-deposited silver lead alloys as bearing surfaces on mechanical parts made from molded plastic materials.

Water pump impellers offer another use for plating on plastics. Most plastic materials tend to be water or moisture absorbent. The less absorbent plastics such as are being used today in the automobile industry for water pump impellers, which are quite expensive, can be replaced by cheaper plastics coated with non-porous films of non-corroding metals such as silver or cadmium. A light deposit of such metals on the less porous plastics will permit them to withstand water submersion for a longer period of time without warping or swelling.

Wherever a combination of conductor and non-conductor is desired in one integral part, plating on plastics should be considered. Plastic radio cabinets can be shielded by plating strips of copper on the inside and grounding them. Plastic knobs can be similarly treated. Moisture-proof condensers of permanent capacity can be made by plating silver on plastic sheets. Sliding variable contacts and electrical hardware of decorative beauty can be produced in a similar fashion.

A particularly interesting application of the new method was in shielding the loop antennae of the radio direction finders of airplanes. The original housing was made of Plexiglas. It was found, however, that the friction of the air stream put a heavy static charge on the Plexiglas which seriously interfered with the operation of the radio. Desiring to continue the use of Plexiglas because of its beauty, the engineers satisfactorily solved the problem by plating thin copper strips on the Plexiglas and then grounding the strips to the body of the plane.

***Cabinet handles and dial knobs of plastic materials plated with metal to improve appearance and to save weight***

Even with the wide variation in temperature that is encountered, as much as 170 deg. F. on the landing field in the sun and down to minus 30 deg. F. in the upper ceiling, the copper strips adhere perfectly to the Plexiglas. In fact, the bond is so strong that the thin copper strips in expanding or contracting bend the Plexiglas slightly.

Reflectors are another field for plating on plastics. Plastics can be easily molded in one piece to calculated curvatures. The curved surface can then be plated with silver, or nickel and rhodium, to give reflecting surfaces of the highest efficiency. Infra-red light reflecting surfaces can be plated with gold; a very thin layer or "flash" is sufficient.

Camera parts particularly those subject to wear can be molded of plastic and plated with metal on wearing surfaces. Lens boards are an example.

### *Heat Resistant Properties*

Inflammable plastic materials can be made heat resistant by plating with metals such as copper and silver. Heat applied at any particular point is diffused and radiated away from the metal surface. By the same token, plastic parts that are not inflammable but prone to damage by heat, can be similarly protected. Even a highly inflammable material such as celluloid, when plated with metal does not readily ignite and if it does, burns very slowly.

Containers for corrosive oils and chemicals now made of glass or expensive metal can be replaced by inexpensively molded light-weight, non-breakable plastics lined with a thin non-porous coating of silver. Many synthetic resins tend to absorb water and other fluids with consequent warping, deformation and discoloration and are therefore unsatisfactory for use. Plastic containers lined with silver by electro-deposition are an answer to this problem. Only very thin deposits of silver need be used (deposits of silver 0.00001 in. thick are non-porous according to the National Silver Producers Research Project) to coat the plastic base.

Other uses that come to mind for electroplating on plastics, are dials, auto and airline accessories where light weight yet the appearance of metal is desired, escutcheon plates, bottle closures, instrument parts and hardware. There is no doubt that further thought will suggest many other uses to the design engineer.

In closing the author acknowledges with gratitude the cooperation of Mr. B. F. Walker of the MetaPlast Inc. in the preparation of this article.

# DISCLOSING AN INVENTION

## *To Prove the Date of Invention*

H. A. TOULMIN, JR.
*Toulmin & Toulmin*

MANY PATENT cases have been lost because of inadequate proof of the date of invention. This is often caused not so much by complete ignorance or neglect as by a misunderstanding of the underlying principles of Patent Law covering the case. Inventors may think they have "taken steps" to prove the date of their invention, but they may have taken either the wrong ones or insufficient ones, so that they stand to lose if they brush up against interference or question of prior use.

One form of proof of date of invention, other than by filing an application, is some written form of disclosure of the invention by way of drawings, photographs that are dated, and written and dated description duly witnessed and signed by the inventor and several witnesses whose acknowledgment is taken before a notary.

This proof should then be mailed to an outsider who can be depended upon to testify that he received the disclosure in the ordinary course of business.

One of the serious mistakes made by most organizations is to have all of the proof of the making of an invention and its disclosure limited within the organization, witnessed only by employees and executives of the organization. The danger of this is that when you are in a contest in a patent office interference, or in a question of prior use before a court, the other side can claim that the material has been fabricated for the special occasion. The only way to meet this issue satisfactorily is to insure that the disclosure has been made to those outside of the immediate organization.

One of the effective ways for handling this is to provide regular forms of disclosure booklets in which all inventive ideas of research, engineering and development departments are recorded. These booklets are regularly mailed out from the organization with a statement of the nature of the invention and whether it is to be protected by application for patent or not. By this method, there is a written record, duly dated, showing the mailing of the disclosure to outside counsel to earn a position to prove by their records that this disclosure has been made. This eliminates all opportunity for opposition to claim that the proof is not genuine and is fraudulent.

With reference to the question of how this proof should be prepared, the conventional way, of course, is to make drawings and sketches. These sketches should be adequately dated and signed by both the inventor and witnesses. The signatures should be in ink and, if possible, the drawings should be in ink because the dates of ink can be readily proved, while the dates of pencil can not be proved. Either regular disclosure booklets, or a bound disclosure record book should be maintained for this purpose. It is wise to keep such disclosure records readily available in every laboratory, on each drafting table and in each experimental shop. The lack of convenient access to such records leads to a neglect of making them.

### *Witnessed Test Runs*

The best type of proof of an invention is to actually make the apparatus, or run tests showing what the inventive process is, or produce the product. When this is done, the tests should be witnessed by responsible people who later can testify as witnesses. Photographs should be taken with these persons included in the pictures and the negatives should be dated the day they are taken. These negatives should be signed by the inventor and the witnesses. This makes a permanent record from which prints can be taken and used as the basis of making disclosures within the organization and to outsiders. The records of the tests themselves should be carefully kept and likewise dated and signed by those present, including the inventor.

The records covering the making of the test apparatus should also be kept apart from the general commercial records of the corporation, because it is the custom of many corporations after two or four years to destroy current records of this character. All of the records with reference to the invention, including the photographs, should carry the same serial number, so that there would be some means for identifying the particular tests, their reduction to practice and have these tests identified by numbers that are carried in a numbered record book of inventions. There is just as much need for keeping record books of invention as there is a need for keeping books of accounts for recording financial and business transactions of a corporation.

### *Adequate Disclosure*

An interesting case on the subject of reduction to practice, which will illustrate some of the rules, is as follows:

To show the advantage of making an adequate disclosure, properly witnessed, we cite General Talking Pictures Corporation v. American Tri-Ergon Corporation, 96 F. (2d) 800, which involved the DeForest invention relating to means for photographically recording sound waves. Here the court held that the applicant DeForest, who was a United States citizen who had prepared a written, witnessed disclosure of his invention while on the ocean on a ship of foreign registry, was entitled to use as his date of conception the first day of his re-entry into the United States. As to the sufficiency of the disclosure the court said:

"In our opinion DeForest disclosed a source of light operable to produce the requisite glow discharge or negative glow by one skilled in the art photographically to record sound for reproduction; that he is therefore entitled to claim at least November 11, 1920, the date of his divisional application as the date of his constructive reduction to practice, if not September 8, 1919, the date of his parent application in which his so-called arc lamp was originally disclosed . . . Can DeForest go further and properly support the proposition which he has advanced, namely, that he conceived the invention in question upon October 12, 1918, and pursuing his conception with due diligence until his work culminated in the applications referred to, is thereby enabled to claim priority of invention? . . . This question turns largely upon the effect to be given to a certain sketch allegedly made by DeForest on the steamship Carmania upon October 12, 1918, and his subse-

quent acts calculated to reduce his conception to practice.

"The circumstances under which this memorandum was made and came into evidence are somewhat unusual. Upon October 6, 1918, DeForest and his patent attorney, Samuel E. Darby, Jr., sailed from New York on the steamship Carmania, a ship of the Cunard Line, under British registry. DeForest testified that upon October 12, 1918, while at sea, he engaged in a conversation with Darby upon the subject of ways to record sound photographically. That to illustrate his views he produced from a book of poetry which he was carrying a piece of 'Carmania' stationery, upon the first sheet of which was written a poem of his own composition, and that he thereupon wrote down, upon the clean side of this first sheet three possible light sources to be used to record sound photographically, and drew upon the bottom of the paper a diagram showing how such should be used. . . .

"According to the testimony, this document was initialed by DeForest and by Darby upon this very occasion, the latter having written upon the paper the letters 'E. & U.' Darby testified that the initials 'E. & U.' meant 'Explained and understood,' and that the conceptions involved were then and there explained to him by DeForest . . . DeForest testified that the paper in question has remained in the book of poems until prior to the trial of the interference when he had found it and mailed it to Darby.

"It is apparent, we believe, that if this paper be what it is represented by the appellants to be, that DeForest conceived the invention here involved upon October 12, 1918."

There was evidence introduced in the case to show that DeForest immediately upon his return to the United States took steps to reduce his conception to actual practice, making various tests, etc., which were witnessed by others. And the court said:

"Such evidence seems to us plainly to support the conclusion reached by the tribunals of the Patent Office giving credence to the 'Carmania' memorandum."

### *Inadequate Disclosure*

As showing the penalty for not making an adequate disclosure which can be corroborated by the testimony of someone outside of the inventor's own organization, we cite the case of Bainbridge v. Walton, 104 F. 808, in which the Court of Customs and Patent Appeals affirmed the Board of Appeals of the Patent Office in awarding priority of invention of Walton on his invention relating to photoelectric tubes, because Bainbridge's evidence of record was insufficient to establish his reduction to practice as earlier than Walton's.

Bainbridge introduced a 17-page exhibit consisting of data alleged to be arrived at from tests conducted by him in September, 1928, as to which tests there were no witnesses, although the immediate superior of Bainbridge testified that he knew in a general way of the work being done by Bainbridge but had no definite recollection of having seen these data at the time of preparation. Bainbridge also introduced a subsequent report which covered the same data but in graph form.

Seven years later Bainbridge had his photoelectric tube tested in the presence of a physicist of the General Electric Company under conditions as nearly as possible like those existing when he made his 1928 tests, and sought by this method to prove what took place in the 1928 tests.

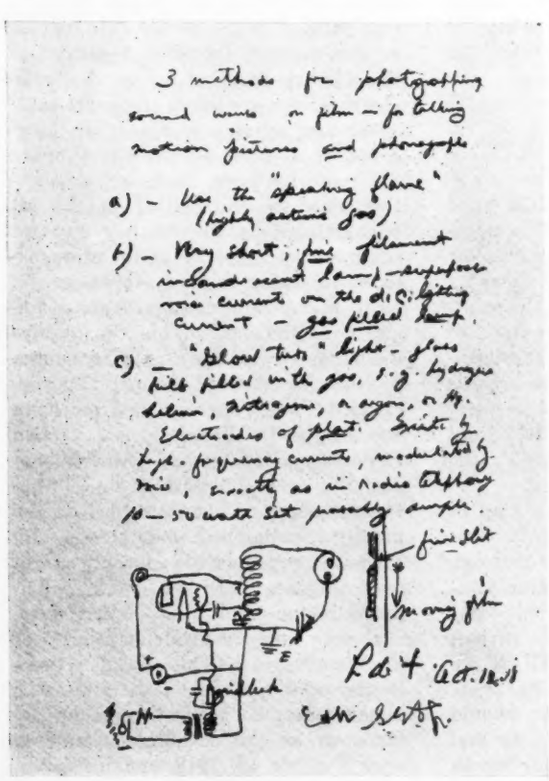
In arriving at its conclusion, the court said:

"Relative to the arguments of counsel for appellant that the witness Dr. Dushman, appellant's immediate superior, must have known in September, 1928 of the results obtained by appellant's tests made during that month and that appellant could not have recorded his data; plotted the results of that data into curves; and then prepared reports, without the work and the results actually having been seen and checked by Dr. Dushman, it may be said that Dr. Dushman does not claim to have seen the tests allegedly performed by appellant, nor does appellant claim that Dr. Dushman saw such tests. Furthermore Dr. Dushman was unable to testify that he had seen the test data either at the time it was prepared by appellant or immediately thereafter. But even had he testified that he saw the test data immediately after it was prepared and that he was satisfied therewith, such evidence would have been insufficient to corroborate appellant's testimony that the data was obtained from actual tests made by appellant.

"The question presented, therefore, is whether the evidence of the tests made in July 1935 of tube No. 19569 (Exhibit *E*) by appellant and the witness Koller may be considered as corroborative of appellant's testimony that he actually tested that the tube in September 1928 and obtained from such tests the data disclosed . . .

"Without intending to be understood as expressing any opinion as to whether such evidence could under any circumstances be considered corroborative in character, it is clear that it cannot be so considered here."

A study of these cases should impress upon the inventor the necessity for firmly establishing proof of the date of his invention by making an adequate disclosure, in writing and witnessed, to some reliable outsider.


3 methods for photographing
sound waves on film – for talking
motion pictures and phonograph
a) – Use the "speaking flame"
(highly sensitive gas)
b) – Very short, fine filament
incandescent lamp – superpose
wave current on the direct lighting
current – gas filled bulb.
c) – "Glow tube" light – glass
bulb filled with gas, i.e. hydrogen
helium, nitrogen, argon, or Hg.
Electrodes of plate. Excite by
high-frequency current, modulated by
wave, exactly as in radio telephony
10 – 50 watts but possibly smaller.
fine slit
moving film
Exhibit E Oct. 12, 18
Edwin H. Colpitts.

*This crude sketch and explanation, written on the back of a piece of Carmania stationery while on board ship, was later upheld by the court as adequate proof of the date of Mr. DeForest's invention. "E. & U." signifies that the sketch had been "explained" by DeForest and "understood" by Darby on that date*

# VELOCITY-GRAPH ANALYSIS

## *For Solving Problems Encountered in High-Speed Motions — Part II*

H. E. GOLBER
*Consulting Engineer*

ANOTHER example in the analysis of design problems will be described in order to show the value of the velocity-graph method discussed in Part I of this article which appeared in the July number of PRODUCT ENGINEERING.

The mechanism which will be used for the example, was designed to pick up and to transfer a piece from one station to another. The mechanism, shown in Fig. 6 as elements in a linkage, consisted of a uniformly rotating crank *FE* which by link *ED* reciprocated the arm *DC* on the shaft *C*. The shaft *C* also carried two arms *CB*, these arms served as a carrier for a heavy gripper placed between them. The gripper reciprocated in the arc *BA*. At *A*, where the gripper picked up a piece, there was an adjustable stop. Note that the reciprocation of the gripper produced an approximate harmonic motion. When originally designed it was thought that the gripper would come accurately to *A*, stop and then reverse.

In practice, however, it was found impossible to adjust *A* so that the gripper would come up to but not knock against *A* for all speeds. As the speed of the machine was changed very frequently, the gripper usually knocked against *A*. At low speeds, the knocks were not very annoying, but at high speeds they were severe.

In an attempt to improve the conditions a speedgraph of the motion of the gripper was made. The speedgraph is shown in Fig. 7 as an harmonic, since the link *BC* is finite instead of infinite the harmonic speedgraph is only approximate. At each node point *A* and *B* the speedgraph has an inclined tangent, that means that at each reverse point in the reciprocation there is a force acting on the gripper.

In an harmonic motion, moreover, it is well known that the force can be compared to an attraction which is proportional to the distance from the middle point *M* of the arc *AB* in Fig. 6. The force on the swinging gripper at *A* is directed from *A* to *M*, and at *B* is directed from *B* to *M*. But what makes the force on the gripper? Obviously, it can only be caused by the motion of the arm *CB*. Since action and reaction are equal and opposite in direction, the gripper exercises on the arm a force which is proportional to the distance from *M* and which always points away from *M*. Therefore, as the machine runs, the force bends the arm always away from *M*, and the force is proportional to the distance of the gripper from *M* or the center of the arc.

Hooke's law states that strain is proportional to stress, this means that the amount of bending of the arms *BC* is proportional to the force. Moreover, in any machine the inertia forces increase as the square of the machine speed. Therefore, the amount of bending of the arm increases as the square of the machine speed.

No wonder it was impossible to choose a definite position for the stop A, since to avoid impact the stop would

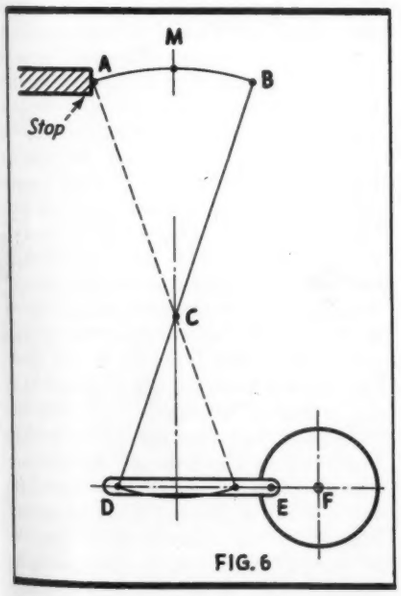



*Fig. 6—Linkage diagram of mechanism which was designed to pick up and to transfer a piece from one station to another*

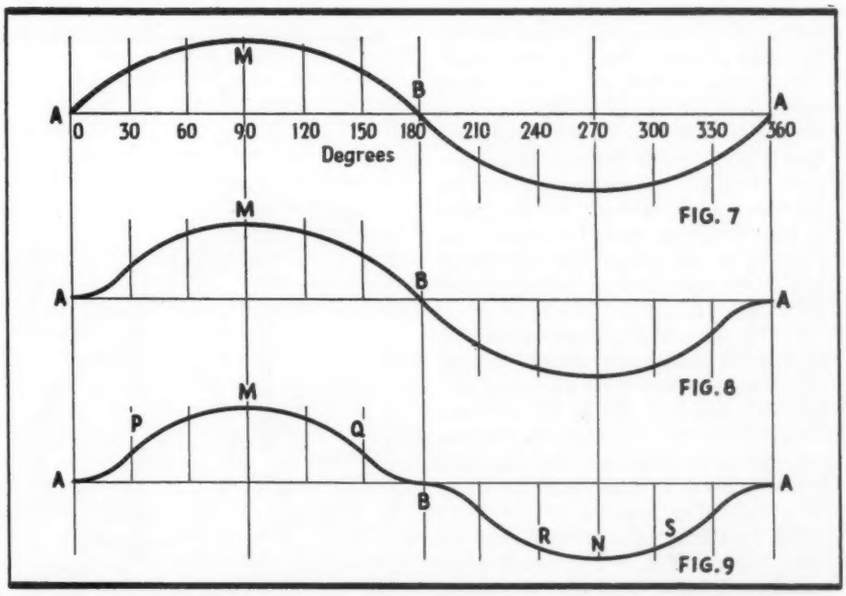



*Fig. 7—Speedgraph of the gripper mechanism shown in Fig. 6, in which the motion is approximately harmonic. Fig. 8—Modified speedgraph with slope at A, or at the stop end of reciprocation, equal to zero. Fig. 9—Symmetrical speedgraph with slope at A and at B equal to zero*

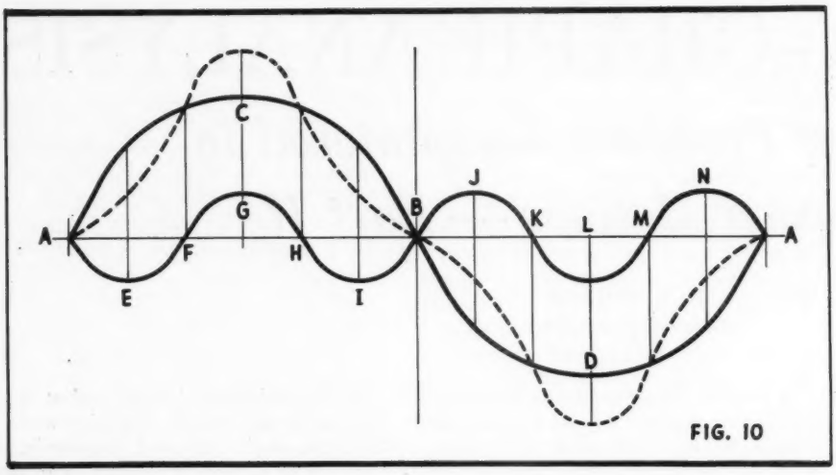



*Fig. 10—Curve shown in dashed lines is obtained by subtracting three waves of small simple harmonic from one wave of a larger harmonic*

have to accommodate itself to the bending arm and would have to be moved out proportionally to the square of the machine speed.

Now what could be done to improve the design? One answer was to make the arm *CB* out of very stiff material. But that already had been done, and had proved insufficient. What else could be done?

Referring to the speedgraph Fig. 7, if only the grade at *A* could be reduced to zero, then there would be no force and so no bend at any machine speed. This suggestion looked promising. In Fig. 8 is shown a possible speedgraph with a slope at *A* equal to zero. The rest of the speedgraph is completely undetermined. Of course, to make the total motion the same as before each area of Fig. 8 and the corresponding area of Fig. 7 must be equal.

The slope in Fig. 8 has been eliminated at *A* but not at *B*. If there is to be a stop at *B* also then a speedgraph like Fig. 9 would be required. Since there was no reason for not making the speedgraph symmetrical the graph in Fig. 9 was adopted. Here again the problem arises; given the speedgraph how does one find a corresponding mechanical drive.

In this particular problem a suitable mechanism was easily found. It was only necessary to remove the crank *EF*, link *ED*, and arm *CD* in the mechanism shown in Fig. 6. The arm *CD* was replaced by a roller arm. On the shaft *F* was placed a ridge cam for operating the roller arm.

But what kind of a curve should the speedgraph in Fig. 9 be? After some searching it was found that the upper half *AMB* was similar to one of the curves discussed on p. 252, PRODUCT ENGINEERING, July 1934, and also in "Kinematics of Machinery," by Albert and Rogers. But the speedgraph has also a lower half *BNA*, and the author does not recall such a graph having been discussed anywhere. However, the graph did remind the author of some curves shown in Fourier's series. Finally the three curves of Fig. 10 were plotted. Here *ACBDA* is an ordinary harmonic, and *AEFGHIBJKLMNA* is three complete waves of a smaller simple harmonic. Moreover at *A* and *B*, the two harmonics seem to have the grades of their tangents equal and opposite. When the smaller harmonic is subtracted from the larger harmonic curve *ACBDA* the dotted curve which looks like the speedgraph in Fig. 9 is thus obtained.

After plotting, the equation of the dotted curve in Fig. 10 was calculated. The difference of the two harmonics gave the speedgraph

$$\frac{dy}{dx} = \sin x - \frac{1}{3}\sin 3x$$

where $x$ is measured horizontally, with $x$ at $AB = 180$ deg.; $y$ is the site. Integrating gives

$(y-a) = -\cos x + \frac{1}{9}\cos 3x$ for the sitegraph,

$\frac{dy}{dx} = \sin x - \frac{1}{3}\sin 3x$ for the speedgraph, and

$\frac{d^2y}{dx^2} = \cos x - \cos 3x$ for the celgraph

In the dotted curve at $A$ or $x = 0$ deg. the acceleration is $(1 - 1) = 0$, and at $B$ or $x = 180$ deg. the acceleration is $[-1-(-1)]=0$, as it should be. The curve seemed to be quite satisfactory, the maximum displacement is 8/9 and 1½ the maximum acceleration.

The mechanism, of course, can be made large enough to give any desired displacement. The maximum accelerations are 1½, but they occur neither at points *A* nor *B* but in between. It is true that the arms bend while accelerating, but in those zones there is nothing to strike so no trouble occurs. The curve seemed to be satisfactory.

After examining the equation

$$y-a = -\cos x + 1/9 \cos 3x$$

the author decided on the construction of a non-cam mechanism to accomplish the movement. Here let it be recalled that an harmonic motion can be produced by a Scotch yoke, in which the slide is a link of infinite length. An approximate harmonic motion can be produced by a link of finite length, as for instance *ED* in Fig. 6. An accurate production of the motion requires two links of infinite length (that is two Scotch yokes) but an approximate motion can be produced by two links of finite length. In the mechanism shown in Fig. 11, the diameter of the pinion is one third the diameter of the gear. On the gear locate a crank pin *A*. Let the radius of the crank be 1. On the pinion at 1/9 of the crank radius the pin *B* is located. The links *AC* and *BD* are extended from *A* and *B*. The links *AC* and *BD* are connected by a planetary link *DC*. At the middle *E* of link *DC* is a stud connection to the swinging arm *EF*. The link *EF* receives a motion approximating the speedgraph Fig. 9. The mechanism is composed only of gears and links and in some ways is preferable to a cam drive.

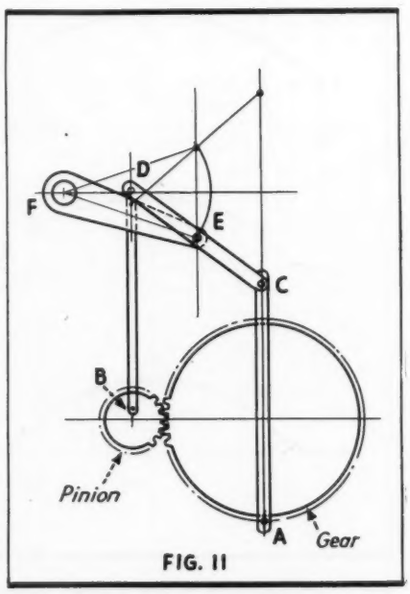



*Fig. 11—Mechanism for producing a motion having a speedgraph similar to that in Fig. 10 shown by dashed-line curve*

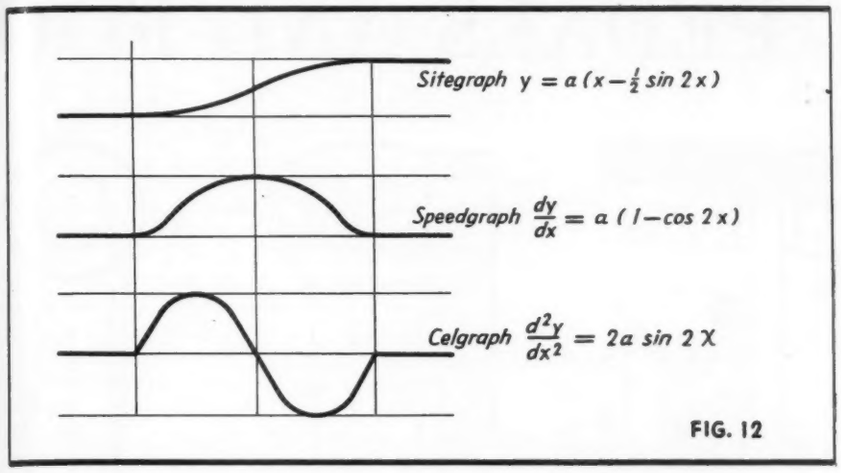



*Fig. 12—Sitegraph, speedgraph and celgraph of a motion that starts and ends with a dwell*

Many other similarly functioning mechanisms can be made. The equations might be

$$y - a = -\cos x + \frac{1}{m^2}\cos(mx)$$

The pinion diameter might be 1/3, 1/5, 1/7, . . . $1/(2n - 1)$ of the gear diameter. Of course the point $B$ would have to be taken at the distance $1/m^2$. If the distance $1/m^2$ is taken as 1/1, the two gears would have the same size and the resulting motion would be zero, which is mathematically correct but practically useless.

The mechanism shown in Fig. 11 is important since theoretically, at least, at any speed it eliminates the node bending of the arms inherent in the Fig. 6 mechanism, so that at the nodes there is no knocking against the stops. There are probably many designs where this mechanism could be applied.

The speedgraph shown in Fig. 10 covers a complete cycle. Very frequently motions occur where there is a dwell, then it is difficult if not impossible to make a link motion to obtain the dwell. It is not difficult, however, to design a cam drive with a dwell.

In Albert and Rogers' book "Kinematics of Machinery," p. 147, it states "All the laws of displacement dealt with up to this point give abrupt changes in the acceleration of the follower, and consequently abrupt changes in the unbalanced forces acting on the frame of the mechanism. To eliminate these abrupt changes during the cycle, the motion of the follower must be such that its acceleration will gradually increase from zero, and then gradually decrease from zero." The book then shows a sitegraph, speedgraph and celgraph which are shown as Fig. 12, except the extensions at the sides which were made by the author.

The extended sitegraph in Fig. 12 indicates that the motion starts from a dwell and ends with a dwell, therefore, the extended speedgraph shows the extension speeds as horizontals which smoothly join the speedgraph curve. With the extensions accelerations are zero, therefore, the extended celgraph shows the accelerations as horizontals. There is, however, a corner or cusp at the beginning and at the end, the celgraph is continuous but not smooth.

Does the non-smoothness of the celgraph produce any bad effects? Would a celgraph that is not only continuous but also smooth be any better? Of course, it is easy enough to draw such a celgraph, and to obtain from it a speedgraph and a sitegraph, but is it worth while? The author does not know of any bad effects traceable to the non-smoothness of the celgraph, maybe there are some. Readers are requested to point out any that they know of or even suspect.

Again, is it even necessary to have the celgraph continuous? Is it not sufficient to make the speedgraph continuous, but not necessarily smooth? Would not a speedgraph like the modified one proposed in Fig. 5, p. 313, July 1940, PRODUCT ENGINEERING, with its cusps be suitable.

The author has pointed out that there were knocks. But they originally occurred in the swinging arm of the mechanism shown in Fig. 6 at the nodes $A$ and $B$. But at these points the old motion had an harmonic speedgraph and celgraph which were both continuous and smooth. The knock was caused by the magnitude of the accelerating forces which bent the arm, so it hit the stop. With the stop removed the knock disappeared. But the sitegraph, speedgraph and celgraph remained the same. The knock was not caused by any non-smoothness and non-continuity of the celgraph or speedgraph.

And again, it has been pointed out that in Fig. 5 (p. 313, July 1940, PRODUCT ENGINEERING) at the speedgraph cusp $D$, there was no knock. So it is not the cusp in the speedgraph, nor the break in the celgraph that produces the knock.

In PRODUCT ENGINEERING, January, 1935, p. 28, it is stated that if a body is suspended by a string, and the string is cut, the body when starting to fall, would hardly be said to have suffered a shock at the moment of start, although its acceleration changed abruptly from 0.0 to 32 ft. per sec. per sec. So what are the objections to abrupt changes in the acceleration of the follower, and to abrupt changes in the unbalanced forces acting on the frame of the mechanism? In reply, it was stated in the foregoing reference, that if the body had been suspended from the string by means of an intermediary spring, the body would then have received a series of violent vibration. This is true. But what does it show? If a steel bar has one end clamped in a vise, and the other end is drawn aside by a string, and the string is then cut, the bar would be thrown into vibration, although it is not falling at all. The vibration of the bar is caused by the opportunity to again assume its unstrained form, and has nothing to do with any of the external forces, like gravity, tending to move it as a whole.

But on the other hand, what harm does it do to make the speedgraph smooth as in Fig. 12 instead of as in Fig. 5 with cusps? It will be found that the smoothing out of the speedgraph makes the resulting maximum grade larger than it would otherwise be. The forces acting on the frame are greater, the tendency to slide on the floor is increased, the parts bend more, and breaks can occur easier.

There is, however, another important reason why the speedgraph sometimes should have no cusps. It is found that in producing the motion by rollcurve gears; the cusps in the speedgraph produce cusps on the gears, and gears with cusps are much more difficult to make than cuspless gears, so for rollcurve gears the speedgraph should not have cusps.

Knocks may occur where the speedgraph has cusps or where the speedgraph does not have cusps. It is sometimes advisable to leave cusps in the speedgraph. It is sometimes advisable to remove the cusps, but in each design the removal of a cusp leads to an increase of acceleration somewhere else, which may be undesirable.

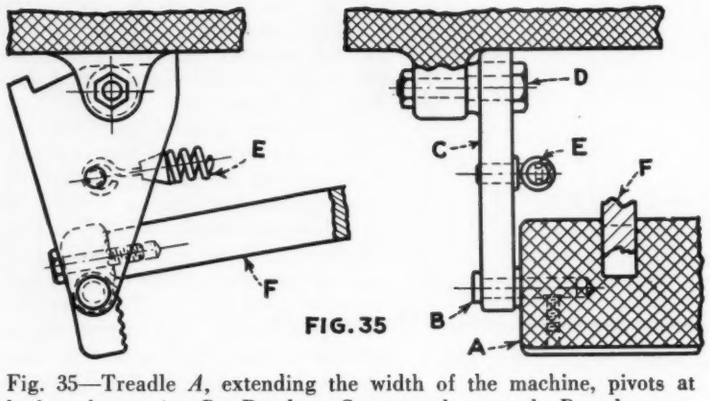



FIG. 35

Fig. 35—Treadle *A*, extending the width of the machine, pivots at both ends on pins *B*. Brackets *C* rotate about studs *D* and are so formed as to limit the travel. Tripping rod *F* is stiff enough to operate in both directions. Spring *E* returns mechanism to neutral.

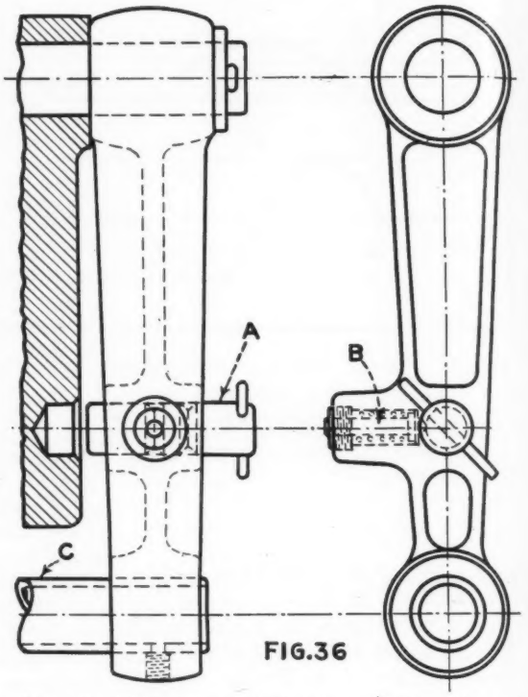



FIG. 36

Fig. 36—When it is desirable to lock this foot treadle in an inoperative position, pin *A* enters hole in the bed casting. Detent *B* holds pin *A* in either locked or unlocked position.

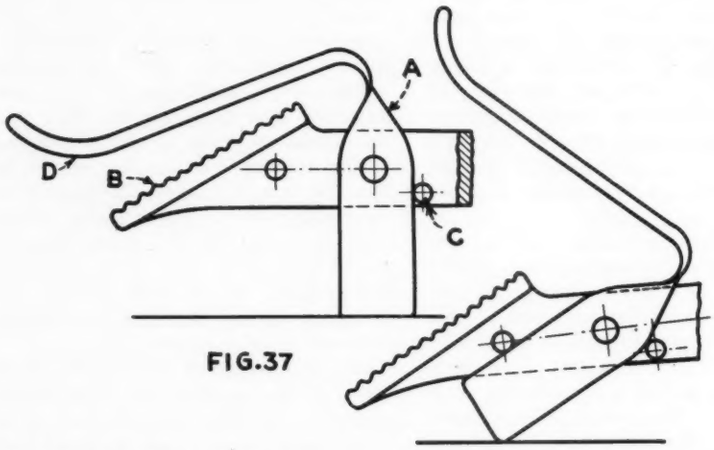



FIG. 37

Fig. 37—Combination safety feature and foot rest is this bent steel bar at *A*. In rest position, the foot rests on *A* which is held by limit pin *C*. To operate, the toe of the shoe enters at *D*, lifting the safety lever *A* and at the same time depressing foot pad *B*.

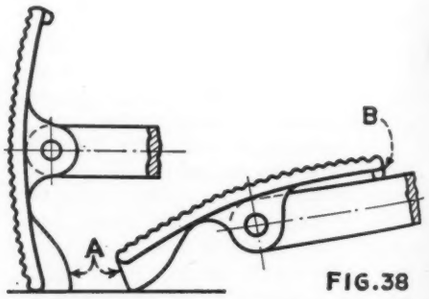



FIG. 38

Fig. 38—For safety, when this treadle is at rest its weighted front end *A* drops to the floor to form a stop as at left. To operate, the toe of the shoe pushes forward against the top of the treadle until contact is made at *B*.

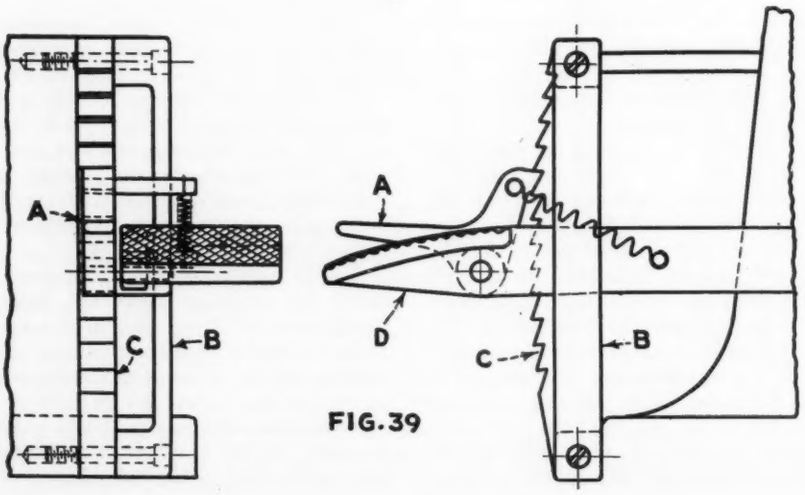



FIG. 39

Fig. 39—Treadle can be held down in any position by this ratchet device. The pawl can be released by sliding foot to left and pressing down on pawl extension *A*. Sideways motion of pedal lever *D* is prevented by retainer *B*.

# OPERATED LEVERS—IV

FRED ADAMS

CORRECT positioning of the treadle is an important factor in pedal design. Where the operator may stand in any of several different positions, depending upon the set-up, the treadle must be movable or extend around the machine. In some cases, foot pads are designed with vertical or horizontal adjustments which permit them to be placed in the position most comfortable to the operator. When the danger of accidental operation is high, some locking safety device should be provided. Several examples of this are shown here. To reduce the tripping hazard inevitably present with extending foot levers, set the pedals in close to the machine base, or design them so that they can be swung out of the way.

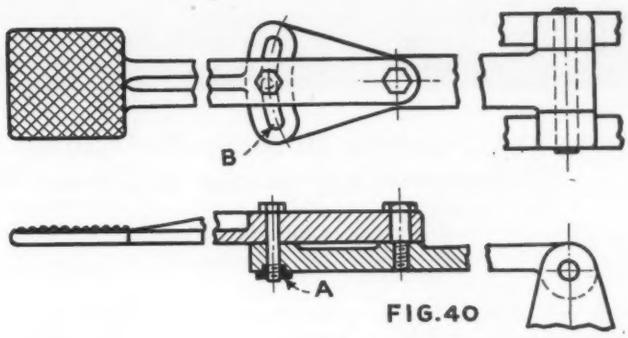
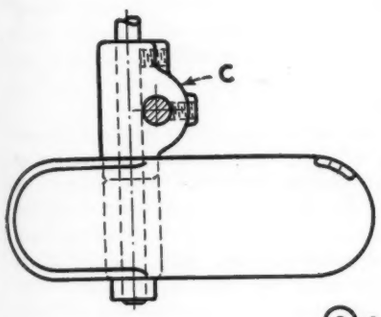


FIG.40

Fig. 40—Circular slot *B* allows a 30-deg. sideways adjustment for the treadle in this two-piece arrangement. Position is locked by screw and T-nut at *A*.



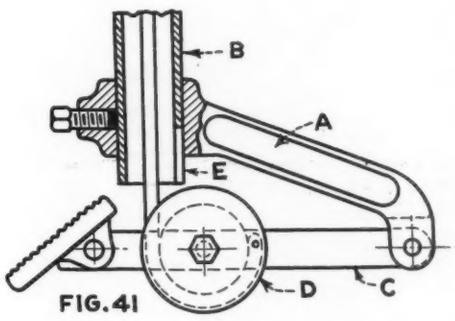



FIG.41

Fig. 41—Vertical adjustment is provided by sliding fulcrum lever *A* on tube *B*. Pulley *D*, to which is attached control cable, is bolted to treadle lever *C* to allow for cable length adjustment. Slot at *E* provides clearance.

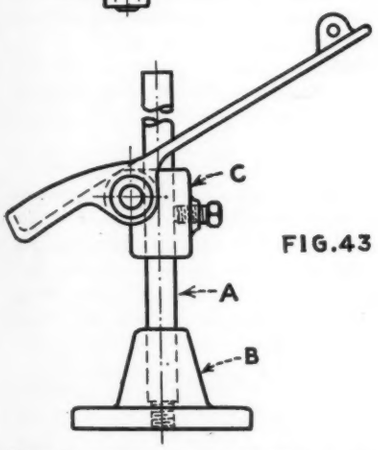


FIG.43

Fig. 43—Bracket *C*, on which pivots the treadle, can be clamped in any position on rod *A* to provide vertical adjustment. Floor stand *B* is screwed to floor. Tripping mechanism attaches to lug at toe of treadle.

Fig. 42—To reduce the danger of tripping over extended levers, many recent machines have pedals similar to this, which hug the machine base as closely as possible.

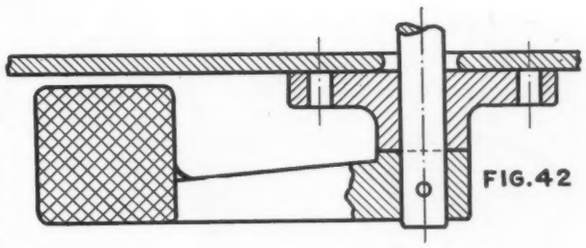
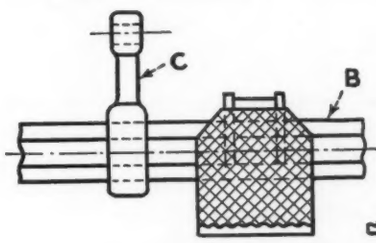


FIG.42



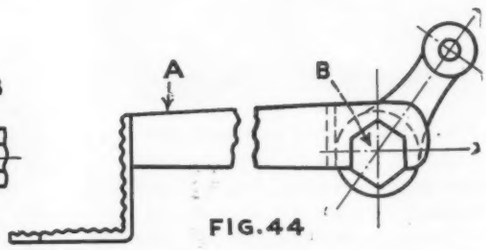



FIG.44

Fig. 44—This treadle *A* can be shifted to any position on hexagonal bar *B* which extends across the front of the machine bed. It can also be lifted off for safety when setting up. Lever arm *C* connects with tripping mechanism.

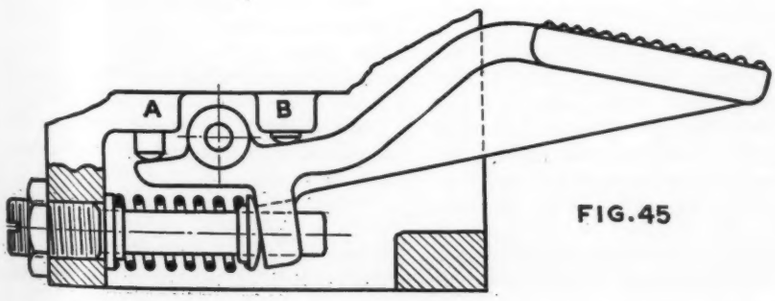


FIG.45

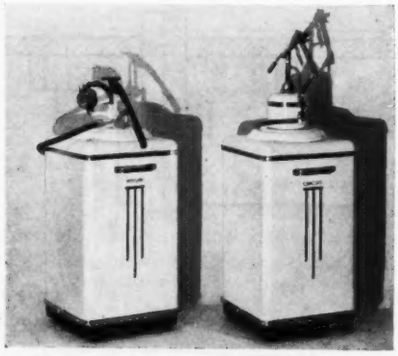
Fig. 45—This treadle operates two valves at *A* and *B*, being pivoted between them. Lower part of the lever is slotted to straddle the spring adjusting screw.

# Question and Comment

## Suggests Housings for Fittings To Improve Appearance of Grease Pumps

CARL P. ANDERSON
*Evanston, Ill.*

In regard to the high-pressure grease pump cabinets that N. V. Smith contends are designed wrong (PRODUCT ENGINEERING, June, page 276), it is distinctly apparent that there are two different types of designing incorporated into the units. The cabinets proper are, to my limited knowledge, of 20th century "streamlining" design, while the upper mechanisms are still back in the fundamental engineering design stage — likened to the practice formerly found in building construction, where a steam pipe would be passed through a living room if it were the economical or convenient thing to do. Thus, the cabinets are clean and sheer in appearance while the parts on top, although they are correct as far as the functional factor is concerned, do not conform to

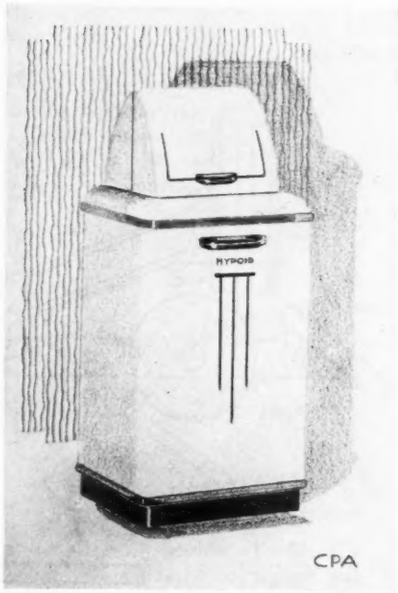


*This is the original cabinet design . . . .*

the clean-cut and unblemished paneling below.

In order to complete my comment I would submit the following suggestion, perhaps far from being correct or ultimate, but still conveying the essence of the point I wish to make.

To redesign the grease pumps I would advise a cabinet that would include the grease fittings within its paneling. If this would be financially undesirable, a "face lift" would be the alternative. This would probably consist of a separate removable housing enveloping the fittings, and harmonizing with the cabinet as it is now. I




*. . . . with a slight change it looks better*

have drawn up this sketch to show how the improved cabinet would look.

In either event, the problem could be solved by creating a series of tentative sketches of housings or complete cabinets, and after choosing the most pleasing one, condensing the fittings, if necessary, so that they will fit inside. The housing, of course, would fold back on hinges and due consideration should be given to convenience.

## Discussion of Acceleration Changes

*To the Editor:*

In Mr. H. E. Golber's article "Velocity Graph Analysis," (PRODUCT ENGINEERING, July 1940, page 311) he describes how he overcame a problem in inertia caused by a too-rapid acceleration of a printing-press bed, and then was confronted with another problem. Briefly, Mr. Golber's second problem was caused by torsional deflection in a shaft which produced a misfit at a critical point in the operation, a situation which was extraneous to the original trouble. These problems are distinct, and illustrate the fact that forces acting on various parts of a machine which are brought progressively or cyclically into operation must be treated separately when the primary analysis concerns itself with the fundamental motion only.

Motion under *uniform* acceleration always produces a straight line on the velocity graph, and the intersection of two of these lines will always be a "corner." Whether these corners are harmful or not will obviously depend on circumstances.

Inertia forces are set up by a change in velocity, or acceleration. Qualitative conclusions regarding these forces can be drawn from an examination of the *displacement* curve for corners; here the criterion is the radius of curvature, depending on the second derivative which of course represents the acceleration. In the case discussed by Mr. Golber the inertia problem was very neatly and rationally solved by examination of both displacement and velocity graphs.

Let us consider the graph of an acceleration as the variable, which is one step farther. Uniform accelerations would be merely straight lines parallel to the time axis, and it is obvious that the junction of two lines representing different uniform accelerations theoretically cannot exist in this graph. There is said to be a discontinuity.

Now there is sometimes confusion in the application of mathematical concepts in the realm of engineering (and even of physics) due to the fact that these abstract concepts simply don't occur. Actually, the sharp corners are always rounded by something, even if only a film of grease. Even an approximately complete analysis would have to take account of so many factors as to render it intolerably complicated for the purpose for which it might be intended. The thing which is quite often disregarded in analysis of machine operation is the elastic deformation of the various parts. Right at this point is where the significance of a change in acceleration can be shown.

Where there is acceleration there is a force producing it, operating as torque in shafts, thrust in gear teeth, tension in belts, tension or compression

in linkage members, and so on. Acceleration and force are proportional, hence at the sharp corners of a velocity curve we must expect a readjustment of the elastic forces. There is likely to be some noise, and in general there is some vibration or quiver of the parts until friction damps out the oscillations. As far as "shock" is concerned, it is a purely arbitrary term which depends on the strength and fit of the machine parts, the nature of the materials involved, and the rate of change in acceleration. For this reason, any quantitative definition of the terms would be hard to make.

In many comparatively simple machines there is likely to be considerable stored-up energy because of elastic forces alone. A one-inch steel cable used in pulling a stump is likely to kill a horse or a man if it snaps. Even twenty feet of half-inch chain is a bad actor when it breaks. Today, in many cases, a very involved study of inertia and elastic forces combined must sometimes be undertaken, especially when these forces are periodic.

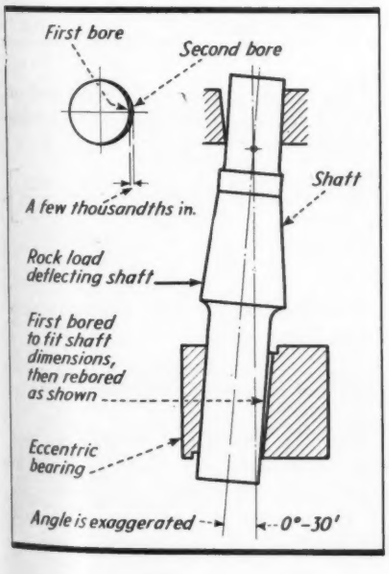
In conclusion let us hope that the very useful "third derivative" will not be thrown on the ash-heap due to a difficulty of application on a momentary misunderstanding; change in acceleration is merely a change in force.

—G. V. BRADBURY
*Kansas City, Mo.*

## Correction For Crusher Shaft Bearing

*To the Editor:*

The sketch showing how the shaft mounting of the Allis-Chalmers Type R reduction crusher allows for deflection, as it appears in the lower right-hand corner on page 252 of the June number, is wrong in the following ways:

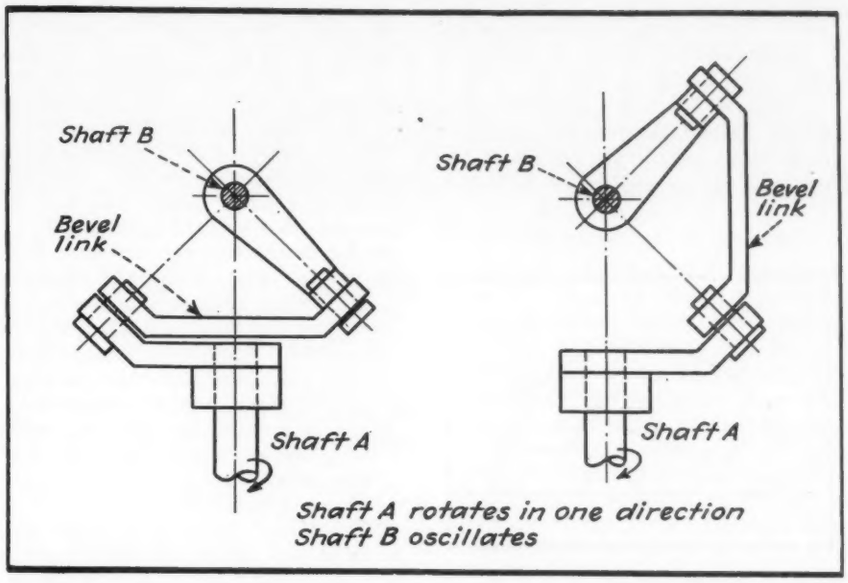



The second bore is wrongly shown parallel to the first bore and is shown on the thin side of the eccentric instead of on the thick side as it should be.

The arrow erroneously indicates that the rock load deflects the shaft in the center away from the thick side of the eccentric. The pressure to crush the rock would naturally apply to the shaft of the crusher above the thin side of the eccentric.

The actual inclination of the shaft from the vertical is about 30 min. instead of 15 deg. In order to illustrate the construction it is naturally necessary to exaggerate this angle of inclination in order to show the second bore.

We have indicated all the above changes on this corrected drawing. The special counterbore of the eccentric, the means for varying the discharge opening in a crusher by varying the quantity of liquid below the crusher shaft, and also the rubber curtain dust seal, all of which features are described in this article, are covered by patents. —R. C. NEWHOUSE,
*Allis-Chalmers Manufacturing Company*




## Oil Circuit Breaker Has Unusual Part

*To the Editor:*

I am inclosing a sketch of an ingenious mechanism called a Bevel Link which I saw in an oil circuit breaker manufactured by Pacific Electric Mfg. Co. of San Francisco. It is used to obtain an oscillating motion of a shaft from the continuous turning of another shaft at right angles to it. Oscillations of 100 deg. or less can be obtained. I understand that this is patented and the patent rights owned by the above company. —PAUL PAGE AUSTIN
*San Francisco, Cal.*

## Trigonometric Method To Determine Angles

*To the Editor:*

Recently in the course of my work I had occasion to lay out some angles of odd values. Not having a protractor of sufficient accuracy at hand I decided to employ a trigonometric method. The device which I hit upon was so simple and effective that I am surprised that it is not given in any of the handbooks or texts to which I have referred. I wonder if any of your readers can tell me whether they have seen it before? Stated briefly in the form of a theorem it is as follows:

*Theorem:* The chord of a circular arc is equal to twice the radius times the sine of one-half subtending angle.

*Proof:* In the accompanying diagram, $AB$ is the arc, $\alpha$ is its subtending angle, $ABD$ is a semicircular continuation, $C$ being the center and $AC$, $CB$, and $CD$, radii. Since $\alpha$ is the external angle of isosceles triangle $BCD$, $\alpha = 2\theta$. Also in right triangle $ABD$ side $AB$ which I will call $L = AD \sin \theta = 2R \sin \theta$. Or,

$$L = 2R \sin 1/2\ \alpha$$

*Corollary 1:* To construct any angle from a given line at a given point, draw an arc with a center at the desired

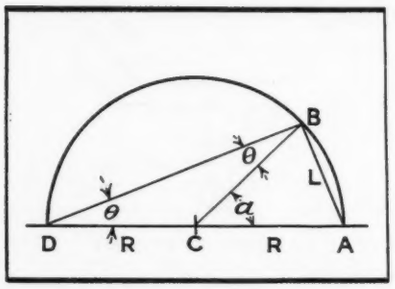
vertex. From the intersection of the arc with the line strike off a chord

$$L = 2R \sin 1/2\ \alpha$$

*Corollary 2:* To determine the value of any angle $\alpha$, draw an arc the vertex of the angle as a center. Scale off the chord of the arc and the angle

$$\alpha = 2 \arcsin L/2R$$

*Corollary 3:* To divide the circum-




ference of a circle into any number of parts, set your dividers to a length $L = 2\ R \sin (\frac{180}{n})$ where $n$ is the desired number of parts.

I will greatly appreciate any information from your readers as to whether the above has been recorded elsewhere.

—Myron K. Drachman
*New York, N. Y.*

## Reply to Comments on Cam Design Analysis

*To the Editor:*

Some of the comments by Mr. H. E. Golber, who discusses my recent article "Cam Design Analysis," seem to require a reply. (Mr. Golber's letter appeared in Product Engineering for July, page 324). The formula

$$W_w = \frac{CF}{1/R_1 + 1/R_2}$$

gives the safe loading for wear, that is, the load which a cam will sustain for a certain number of cycles. With metallic materials the rapidity of the cycle does not influence the number of times the load may be repeated.

Confusion exists because ball bearing catalogs express the life of a ball bearing in hours and r.p.m. instead of in total number of revolutions. Obviously, the life in revolutions is used up faster at higher speeds than at lower ones, and since it is desired to obtain the same life for all speeds, the load diminishes as the speed increases.

Of course, the total load to which a cam is subjected during its operation depends on the speed because this load is the sum of the work load, the acceleration load, and the increment load due to inaccuracies of manufacture. The same is also true for ball bearings, gears, or any moving machine element.

A complete discussion of this theory as applied to gears is given in an A.S.M.E. publication "Dynamic Loads on Gear Teeth" by Prof. Earle Buckingham. The same principles apply to cams. The writer would like to add, however, that no data are available as yet for determining the increment load on cams as has been done for gears.

The writer attempted to avoid any impression that the choice of cam curves for particular problems is arbitrarily limited. Obviously, each cam problem is an individual one and consideration should be given to the pressure angle, velocity, and acceleration characteristics of any curve, or combination of curves, which are to be employed.

The points raised concerning the value in cam design of curves having zero acceleration at the start and finish of the track are well taken. This whole subject is now being studied with the aid of an oscillograph which records stresses, accelerations, and velocities in cam driven mechanisms operating under all types of loading.

A difference of opinion always seems to exist as to the relative merits of mathematical and graphical solutions in the design and analysis of many machine elements. Graphical and other short-cut solutions are based upon mathematical solutions which have been modified for commercial reasons, such as ease of machining, standardization, materials adaptability, etc. With this in mind, we can settle the controversy by giving proper consideration to the severity of the requirements for the mechanism—requirements which determine the accuracy necessary.

—Wade H. Shorter, Jr.
*United Shoe Machinery Corporation*

## Turntable Drives Given In R.C.A. Publication

*To the Editor:*

I note that Mr. Samuel Wesert is looking for a substitute for a flywheel to eliminate sudden fluctuations in speed of the turntable of a portable machine. Mr. Wesert's letter appeared in Product Engineering for July, page 325.

Mr. Wesert would undoubtedly be much interested in a comprehensive article called "Review of the Quest for Constant Speed," in the R.C.A. *Review*, Vol. II, October 1937, beginning on page 220. Mr. E. W. Kellogg, a member of the R.C.A. Research and Engineering Staff presents here a good discussion of the problem, and includes sketches of many mechanisms used to stabilize the speed of sound recording and reproducing equipment.

This magazine is published by R.C.A. Technical Press, 75 Varick St., New York, N. Y.

—W. Everett Swift
*Worcester, Mass.*

# *Can You Work This One?*

H. E. SMITH

***This month's problem—***

## *Count Your Cards*

While dealing regularly in an ordinary bridge game, South dropped some of the undealt cards onto the floor, but retained the rest in his hand. He then observed that the number of cards on the floor was two-thirds of the number he had already dealt to West, and that the number already dealt to East was two-thirds of the number of undealt cards still in his hand. How many cards had been dealt?

***Solution to July problem—***

## *Wine Dilution*

The first slug of water which drops into Julius' 10-gal. container of wine causes 0.001 gal. of the 60 per cent wine to overflow and changes the percentage of the remaining wine as follows, where $W$ = amount of wine, $T$ = total capacity of barrel:

$$\text{Per cent after first drop} = 100 \times \frac{W - 0.001\ W/T}{T} = 100\frac{W\ (T - 0.001)}{T^2}$$

The second drop causes 0.001 gal. of this percentage to overflow and changes the percentage of the remaining to

$$\left[\frac{W\ (T - 0.001)}{T} - 0.001\frac{W\ (T - 0.001)}{T^2}\right] \times \frac{100}{T} = 100\ \frac{W\ (T - 0.001)^2}{T^3}$$

Similarly, for the third drop and thus for $n$ drops

$$\text{Per cent wine} = \frac{100\ W\ (T - 0.001)^n}{T^{n+1}}$$

Then, as there are 12.5 drops per day for 40 days, $n = 500$ and by substitution of this with $W = 6$ and $T = 10$ the answer is found to be 57.102 per cent.

# News and Summaries

## Photographic "Mechanical Draftsman" Saves Time and Money for Aircraft Engineers

***New camera process, which lowered Martin's 1939 costs by $80,000, reproduces drawings on any surface, is adaptable to all industries***

MUCH OF THE TEDIUM and expense of the drafting work necessary before engineering designs are ready for production has been eliminated at the Glenn L. Martin airplane plant in Baltimore by a revolutionary new camera process. In the process, through which Martin saved $80,000 last year in drafting costs alone, original engineering drawings are photographically reproduced directly on metal, wood, cloth, paper, or practically any other kind of a surface. Principal uses of the method are for redrafting, and for the making of templates, mock-ups, small-scale experimental models, and "shrink layouts."

Large original drawings are photographed by a gigantic camera. The negatives are developed and the images projected back to large sheets of aluminum alloy metal (or other material) whose surfaces have been sensitized with a special emulsion. When the exposed sheet is placed in developing tanks, the drawing appears on the surface in exact scale—or in fractional or multiple scales, if so desired. In a matter of minutes any number of drawings which might have required days in redrafting can be reproduced. Engineering work is speeded tremendously. Tool designing and tool making get under way more quickly and more accurately. Design changes can be made more rapidly.

One of the most important jobs of the big camera is in conjunction with Martin's lofting system. Down in the basement of the engineering building is a long, chalk-white floor, slightly raised above the building floor. Here airplanes and airplane sections are drawn out in full scale by engineers who walk and crawl over the floor, wearing flannel window-dressers' slippers over their shoes.

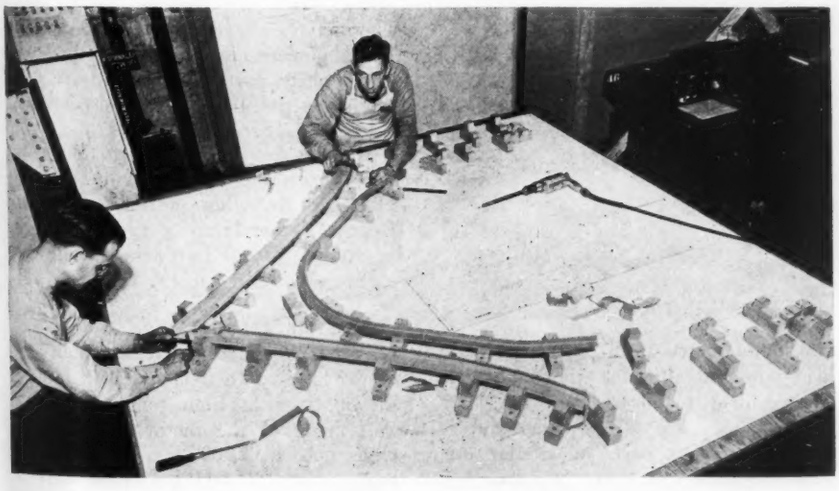
To this floor come stress analysts to decide what trusses and stringers and braces will be necessary to carry the load of the assemblies. Tool designers plan out their tools and dies. Production planners envision shop and assembly line operations. Details are sketched into the full-scale drawings.

Between the sweeping contours drawn on the loft floor, the details of the sections of the airplane are pencil-drawn on the loft layouts, which are large sheets of aluminum alloy coated white on one side. Few dimensional figures are necessary because the sections are in full scale. When a loft layout is finished as a drawing, it goes to the big camera and as many copies as necessary are struck on white-coated metal sheets that become duplicates. The original goes into a file for permanent record.

Templates are made in the tool design department by positioning a layout duplicate over a piece of sheet iron and drilling little holes along the outline of each part for which a tool or die must be made. When the photo-drawing is lifted, the contours are clearly marked in the sheet iron by the drill. The templates are then cut out of the sheet metal and sent to the shop for manufacturing.

The system is also of inestimable value in the making of "mock-ups." Since a full-scale model of every new airplane type must be built first of wood to give engineers, tool designers, and production planners their final information, the ability of the "mechanical draftsman" to photograph drawings directly onto the surface of both painted and unpainted wood saves time and effort. Skilled craftsmen in Martin's woodworking shop can work directly on many of the mock-up parts without constant reference to drawings.

Still another interesting function of the new process is in the making of "shrink layouts." Because zinc and other die casting metals shrink considerably on cooling, it has always been necessary either to make new drawings to allow for this shrinkage or to use a shrink-scale. But, because the shrinkage is a known factor, a simple calibration of the camera lets the lens do in a moment what might consume many hours of time by older methods.



*Experimental parts are made directly on full scale photographic reproductions*

## A.S.T.E. Becomes Member of A.S.A.

BECOMING A MEMBER-BODY of the American Standards Association following action taken at its annual meeting in New York, The American Society of Tool Engineers has received a full voice in the affairs of the Association. The A.S.T.E. will be represented on the Standards Council, the Mechanical Standards Committee, and on a number

of projects in which its members are interested.

The tool engineer has a particularly important interest in the national standardization program, stated the Association, because he is responsible for getting into production the idea conceived by the designer.

Increasing attention is being given to corordination between the work of the designer of the product and the work of the tool engineer. The success of a product on the market, and as a result the very existence of a company, may depend not only on how the product is designed for performance and appearance, but also on how it is designed with a view to method of production.

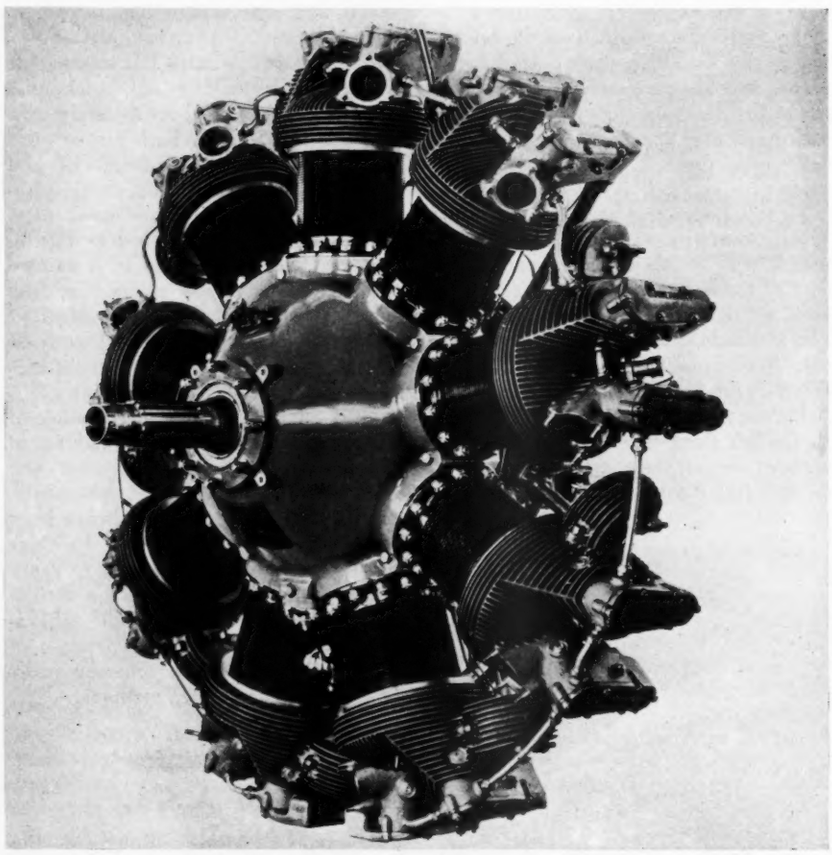
The American Society of Tool Engineers, which has already been active in standardization work for some years, was started in Detroit in 1932 and now has 4,000 members in local chapters in nearly 30 cities. Its president is A. H. d'Arcambal of the Niles-Bement-Pond Company, Hartford, Conn.

## Plastics Institute Opens in September

WITH COURSES on all phases of plastics manufacture including application, fabrication, design, research and sales, the Plastics Industries Technical Institute will open on September 16 in Los Angeles, recently announced E. F. Lougee, Chairman of the Board of Governors and former editor of *Modern Plastics*. J. Delmonte, former instructor in plastics at Armour Institute, author of the new book "Plastics in Engineering," and well known to readers of PRODUCT ENGINEERING as a contributor of many plastics articles, will supervise instruction as Technical Director.

The educational program as planned embraces a thorough study of all plastic materials; their history and background; methods of classification; their relationship to various engineering and industrial fields; their nature and properties; and forms in which they are available for manufacturing purposes.

This general program will be followed by specialized training in mold design and molding; methods of laminating and types of materials used; methods of casting plastics and their utility; fabrication; styling and design; finishing materials; extent of applications including study of its market.



**Diesel aircraft engine,** weighing 2 lb. per hp. (slightly lighter than engines used in German long-range bombers) is radial air-cooled, 4-cycle Guiberson type with 9 cylinders. Advantages over gasoline engines are substantial savings in fuel costs, use of non-explosive fuel, and maintenance of 75 per cent of full load power at altitudes where gasoline engines drop to 50 per cent full load power. Parts are 90 per cent interchangeable with parts of similar engines developed by Buda Company for Army tanks.

## *Meetings*

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Pacific Coast Convention, Los Angeles, Calif., Aug. 26–30. H. H. Henline, secretary, 33 W. 39th St., New York, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Fall Meeting, Spokane, Wash., Sept. 3–6. C. E. Davies, secretary, 29 W. 39th St., New York, N. Y.

SOCIETY OF AUTOMOTIVE ENGINEERS—National Tractor Meeting, Schroeder Hotel, Milwaukee, Wis., Sept. 24–25. John A. C. Warner, secretary, 29 W. 39th St., New York, N. Y.

## *Do You Know That—*

TOUGHEST BRAKING PROBLEM occurs in aircraft, where two brakes may be called upon to bring a 40-ton load traveling at 100 m.p.h. to a stop within a few hundred yards. Metallurgists are now trying to develop a brake drum material that will not heat-check. (18)

RED LETTERS on aluminum for night driving, and white on black for daylight driving have been determined the best color combinations for automobile license plates. (19)

COLORED RIVETS, in bluish-green, dark red or black are used in quantity production in order to save time in assembling, obviate mistakes and help workers identify parts more readily. Coloring is done in rustproofing process. (20)

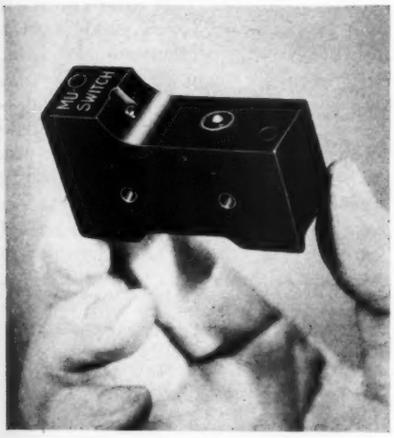
RUBBER can now be given the property of conducting electricity without affecting its other normal qualities. Degree of conductivity can be varied in rubber of all hardnesses with the exception of soft rubber. (21)

NEW METAL, containing only 7 per cent iron, has greater strength than any known steel. To demonstrate its elastic qualities at high temperatures, a bell made of the metal rang with a clear note at 1,100 deg. F., at which temperature a steel bell gave only a dull thud. (22)

# New Materials and Parts

## *Millibreak Switch For 2 Kw. Load*

Type D Mu-Switch handles a d.c. load of 17 amp. at 125 volts, or 8.5 amp. at 250 volts, with an actuating movement of 0.0015 in., and an operating pressure as low as 24 oz. It occupies a space only $2\frac{15}{16}$ in. long, $\frac{13}{16}$ in. wide, and $1\frac{3}{8}$ in. high. With contacts made of a special non-sticking alloy, and a



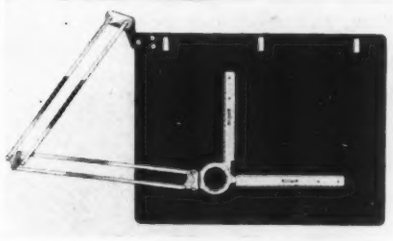

powerful magnetic blow-out device for arc suppression, this switch does not need capacitors or resistors to protect the contacts. Molded plastic housing withstands temperatures up to 900 deg. F., and can be screw-mounted. Switch is normally closed, single pole, single throw. Mu-Switch Corp., Canton, Mass.

## *Ductiloy Changes Name To N-A-X High Tensile*

The special low alloy steel known to the trade as Ductiloy will henceforth be marketed under the trade name of N-A-X High Tensile. Under the new trade name, there will be no change in the chemical or physical properties of the product. This high tensile, high ductile alloy was developed by Great Lakes Steel Corporation engineers to meet demands for a steel combining cold forming and deep drawing properties and weldability with the added strength and resistance to corrosion and abrasion provided by alloyed mild steel. The product has high resistance to impact and fatigue. In announcing the change in the trade name, the company states that the step is being taken "to identify more closely the name of this alloy steel with the corporate name of the parent company." National Steel Corp., 2800 Grant Bldg., Pittsburgh, Pa.

## *Drafting Machine*

Small drafting machine, made of stainless steel with accurate graduations, has a vernier attached to the back plate which makes it possible to set the machine to ½ deg. A latching feature makes it possible to latch the protractor accurately at 0, 30, 45, 60 and 90 deg. The arms are made of chrome steel with a bright chrome finish on one side and dull chrome on the bottom side. All other parts are finished with a dull chrome plating. Finish on the protractor is a circular polish, making it easy to read without tiring the



eyes. Boards are of green colored Masonite. Available in mounted or unmounted models for 12x18, 15x20, and 18x24 in. sheets. The portable drafting machines will take the standard Drafto interchangeable scales. Models PE 30-35. Drafto Co., Cochranton, Pa.

## *Screw Steels*

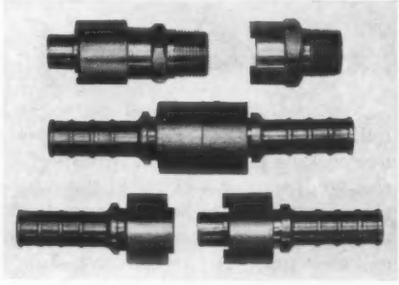
A new bessemer screw steel and a new open hearth screw steel, equal or superior in machining qualities to screw steels formerly available, superior in soundness and free from variation in machinability have recently been placed into production. The steels are claimed to be dense in structure and free from defects which cause internal seams and difficulties that lead to rejection of finished parts and which shorten tool life. The bessemer steel, Union Maxcut, has physical properties comparable to S.A.E. X 1112. Parts show a smooth, fine finish when machined at 280 surface ft. per min. with a basic feed of 0.0095 in. and an average tool life of more than 11 hr. The open hearth steel, Union Multicut, has physical properties similar to those of S.A.E. 1115. Parts can be machined to a fine finish at 275 ft. per min. with a basic feed of 0.0087 in. and an average tool life of better than 8 hr. Union Drawn Steel Div., Republic Steel Corp., Cleveland, Ohio.

## *Sensitized Linen Photoprints Tracing*

Sensitized linen will reproduce a master positive copy from a pencil drawing for use in every respect like a tracing. This copy is made by contact photoprinting in ordinary office light, with complete elimination of ink tracing by hand. Heccotex is properly sized and waterproofed to take an office-light emulsion with a non-halation backing. The linen does not shrink or stretch when immersed and therefore makes possible true-to-scale printing of blueprints or other types of drafting room reproductions. It is also possible to make Heccotex reproductions from old, worn-out tracings. Available in sizes from 12-in. to 36-in. rolls, as well as in cut sheets of whatever size desired. Hunter Electro-Copyist, Inc., Syracuse, N. Y.

## *Hose Couplings*

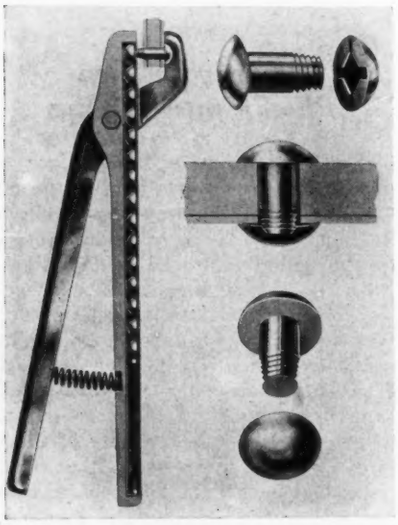
Cast bronze hose couplings for joining similar or dissimilar sizes of rubber hose on air, water, steam and gas lines operating up to 200 lb. per sq. in. In



addition to quick opening and closing features, Fuline hose couplings employ a positive locking device, thus assuring increased safety for workmen. When connection is made, there is no chance of lock spring escaping from sleeve and causing possible accident. This safety feature is particularly valuable when coupling is employed on air compressors and for steam connections in boiler rooms. Standard sizes are available for ⅜ in., ½ in., and ¾ in. hose. Larger sizes can be built to specifications. Pittsburgh Brass Mfg. Co., 3247 Penn Ave., Pittsburgh, Pa.

## *Spring Locking Button*

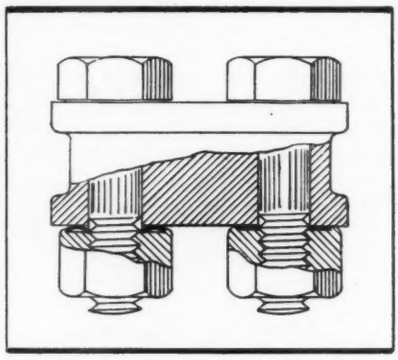
New type of patented fastener and spring locking button, for use where various types of speed nuts are applicable, will not loosen from vibration



when assembled, and presents a finished appearance. The fastener stud has a tapered shank with sawtooth circumferential grooves. The spring locking button, made of thin sheet steel with spring locking lugs extending inward from the edges of the shell, can be quickly snapped onto the stud to make a tight, shakeproof fastening. Fastener can be made from many alloys and the spring locking button can be made in any size or shape. Hopkan Rivet Co., 128-130 Latham St., Pittsburgh, Pa.

## *Lock Nut*

New, self-contained, all metal, lock nut, known as the An-cor-lox, utilizes a new locking principle that permits effective, and positive locking of the nut to the bolt, not to the work. Pressed into a recess in the nut, and an integral part of the nut, is an arcuate-shaped metal locking ring. When the nut is spun on the bolt and drawn up to the desired degree of tightness, the locking ring is expanded by the locking pressure into the root of the bolt thread, giving a tight grip which holds se-



curely under all heat conditions and vibration. Extra-length bolts are not required. The lock nut does not damage the bolt thread nor mar the surface of the work, and the same nut can be used over again without loss of locking effectiveness. Available in all standard sizes and in all metals. An-cor-lox Div., Laminated Shim Co., Inc., 64 Union St., Glenbrook, Conn.

## *Magnetic Alloy*

Composed of cobalt, vanadium and iron, this alloy can be made to hold more permanent magnetism than any

commercial material. It can be drawn and rolled, a property of decided advantage in many applications, and not possessed by other permanent materials. For example, it has been rolled into tape 1/500 in. thick and 1/20 in. wide. The new material is composed of 6 to 16 per cent vanadium, 30 to 52 per cent iron, and 36 to 62 per cent cobalt. From the molten state it is cast into an ingot, which is hot-swaged to ¼ in. diameter. It is then drawn into wire or rolled into tape, as desired. Finally, it is heat-treated to develop its magnetic qualities. It is possible to weld pieces of most high-permeability materials to the magnet and heat-treat them both together. Bell Telephone Laboratories, 463 West St., New York, N. Y.

## *Alloy for Heavy-Duty Gears and Shafting*

S.A.E. 4815, a carburizing nickel-molybdenum steel, has recently come into prominence for heavy-duty gear and shafting applications. In the normalized condition, its machining properties compare favorably with S.A.E. 4615, and S.A.E. 2315. Carburizing practice is much the same as for S.A.E. 2315. An outstanding advantage of the new alloy is the high core strength which can be developed by a single quench treatment. In sections up to 1 in., tensile values up to 200,000 lb. per sq. in., and yield strength in the neighborhood of 165,000 lb. per sq. in. can be developed in the core, together with hardnesses up to 415 Brinell, providing excellent backing for the case under crushing loads. The tough, fine-grained case provides excellent resistance to wear, spalling and pitting fatigue. Joseph T. Ryerson & Son, Inc., 16th and Rockwell Sts., Chicago, Ill.

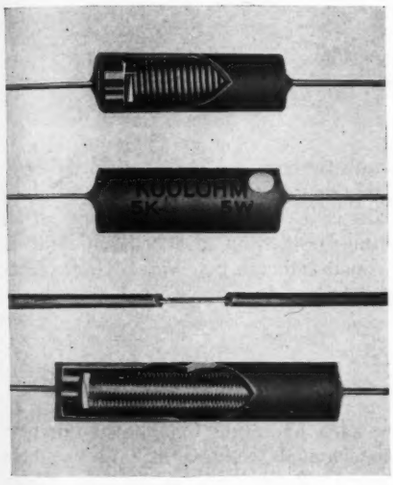
## *Wire Rope Connectors*

Improved Electroline-Fiege connector, which damps line vibration stress, grips the cable with a graduated compression, feathering off from maximum at the rear to zero at the front. This design prevents weak point crystallization at the point of connection and thus insures longer rope life. The connector consists of three simple units: a sleeve which slips over the end of the wire

rope, a tapered plug which is inserted to separate and hold the strands of wire in the sleeve and a covering socket which securely locks the cable. Installation can be made with ordinary mechanic's tools. Available in black, hot-galvanized and cadmium-plated steel. Also available in bronze, stainless steel and monel metal for rope sizes under ½ in. Electroline Co., 4054 S. LaSalle St., Chicago, Ill.

## *Resistors*

Representing a unique departure in the construction of wire wound units, the wire used in the windings of these resistors is insulated with a hard, moisture-proof insulation. It quickly conducts heat away from the wire and is not damaged by bright red heat. This feature makes possible interleaved wind-




ings wherein wires touch but do not short, and permits the use of larger, stronger wire to give higher resistances in smaller size. Interleaved windings also permit a guaranteed accuracy of 5 per cent or better. Resistors are electrically insulated in a dark brown ceramic shell. An outstanding feature is a red Teledot on the end of each resistor which automatically changes color when a 25 per cent overload occurs. When the overload is removed, the Teledot returns to its original red color. Available in 5-watt fixed types; 10-watt fixed; 10-watt adjustable; 10-watt non-inductive. Also in 25, 50, 100, and 200 watts. Sprague Products Co., North Adams, Mass.

## *Worm Speed Reducer*

Intermediate line of worm reduction speed reducers, designated as Type 2⅝ A, weighs 22 lb., has base dimension of 7½ x 5 in., and a height of 7 in. They are capable of handling inputs from ¼ to 2 hp. at 1,800 r.p.m., and ⅛ to 1½ hp. at 1,200 r.p.m. Ratios range from 4 5/6–1 to 100–1. The worms are made of alloy steel with hardened and ground threads. Worm wheel is of nickel bronze. Shaft mountings are on full ball bearings. Gears, wheel, and worm are

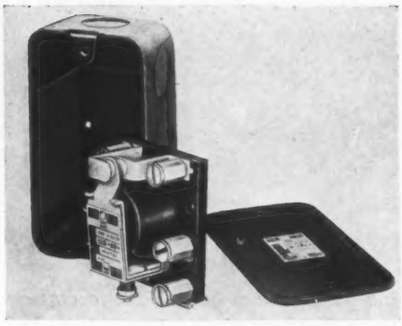
assembled in a semi-steel, oil tight housing with bearing supports for both worm and wheel machined in one casting to insure permanent alignment. Oil seals are used on both input and output ends to eliminate oil leakage. Abart Gear & Machine Co., 4832 W. 16th St., Chicago.

## *Molding Compound*

Arc-resistant phenolic molding compound, called Durez 8685, is formulated specifically to prevent tracking where there is combined electric spark and rubbing action. It has very high resistance to carbonization under an arc. While slightly slower to cure in the mold, its electrical properties are materially increased by baking after molding. It will hold its high dielectric strength when used at moderately high temperatures. Does not crack under the expansion and contraction of metal inserts around which it may be easily molded. Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y.

## *Midget Relay*

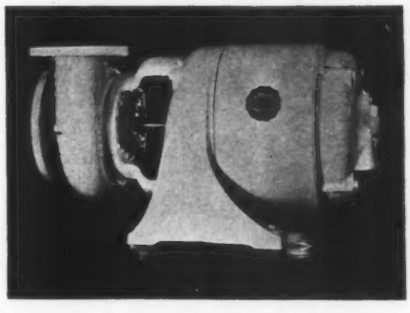
Designed for use on either a.c. or d.c., this relay is available with contacts arranged for single pole, normally open, normally closed or double throw. The relay is rated to handle approximately 1 hp., and is furnished with coils for operation on standard voltages up to 115 volts at standard frequencies. For ratings up to 230 volts, coils can be supplied for not less than 50 cycles. With overall bakelite base



dimensions of 2⅝ × 1⅞ in. on an overall depth of 1½ in., the new relay can be mounted in the familiar wall type pushbutton box. Relay is known as Bulletin 105. Ward Leonard Electric Co., Mt. Vernon, N. Y.

## *Pyramidal Base Motor*

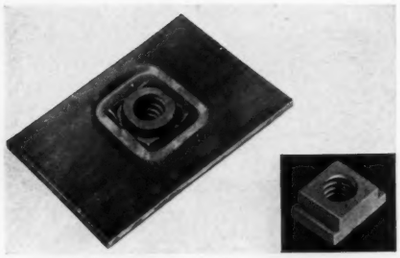
This new pyramidal base motor is claimed to do away with the possibility of misalignment which often develops in connecting a horizontal centrifugal pump or similar device to its motor. The motor support on which the pump casting is attached carries the load of the pump instead of permitting any of the weight to be imposed on the shaft. All hold-down bolts are applied to one rigid casting. There are no joints be-



tween parts which might be pulled apart by fastening the unit to an uneven surface. No coupling is required, one shaft only being used. U. S. Electrical Motors, Inc., 200 E. Slauson Ave., Los Angeles, Calif.

## *Lock Nuts*

These new nuts, punched out of a drawn flanged section, provide a new method for increasing the thread area in sheet metal, making practical the use of lighter gage metals and simplifying assembly in inaccessible places. The small portion of the nut is inserted in the square hole that has previously been cut in the metal, protrud-



ing just enough for the four corners to be clinched with a swaging tool. The nut will not work loose, and any variation in the thickness of the metal is automatically corrected. Available in 36 different types and sizes. FabriSteel Products, Inc., Kerr Machinery Bldg., Detroit, Mich.

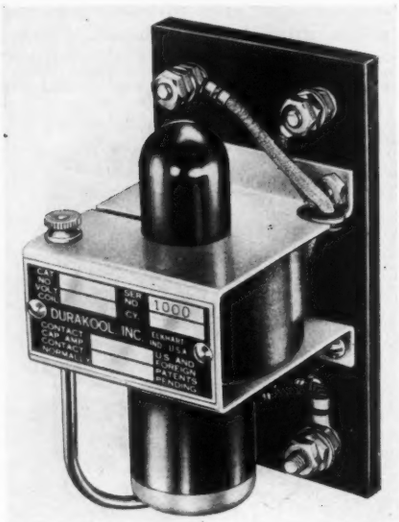
## *Ball Bearing*

New maximum-capacity, double-roll ball bearing is designed for more liberal load ratings because of the greater number of balls in each row supporting the races. Balls are assembled through filling slots in the faces of both the inner and outer race. During operation, however, the slot causes no ball interference because the rigidity resulting from the angular contact fit-up does not allow

for race displacement. Bronze retainers assure durability, cool operation and long bearing life. Ball pockets are cylindrical in contour, which results in a line-contact, thereby reducing friction and decreasing ball wear. McGill Mfg. Co., Valparaiso, Ind.

## *Unbreakable Mercury Relay*

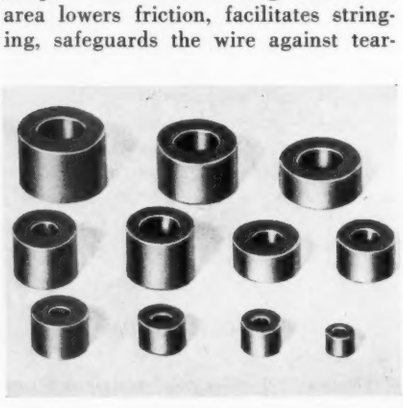
Mercury relay utilizes the unbreakable metal body of the Durakool mercury switch and the displacement principle with solenoid actuation. The contact structure is hermetically sealed, making the relay especially suitable for use in corrosive or explosive atmospheres. It can be operated up to 300 times per min. There is little friction and no wear in operation. No glass is used in its construction. The durable metal body is specially treated to hold a gas at a pressure of 4 atmospheres, an important feature in the reduction




of ionization between the contacts. Contact resistance is as low as 0.002 ohms. On a.c., as little as one watt is required for normal closing operation, and only 1.5 watts for normal opening operation. On d.c., the operating energy required is but 0.25 watts. Durakool, Inc., 1010 No. Main St., Elkhart, Ind.

## *Motor Shunt Beads*

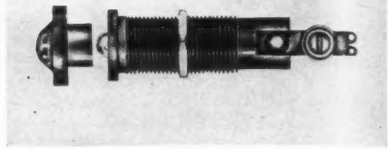
New glazed ceramic shunt bead has high mechanical strength, density and electrical resistance, even at elevated temperatures. The smooth glazed inside area lowers friction, facilitates stringing, safeguards the wire against tear-



ing during assembly and use. Smooth edges throughout are a feature of the new design. The new beads are of traditional dark color so they will not show grease or dirt. These beads have been developed to replace imported glass beads which cannot now be obtained. American Lava Corporation, Chattanooga, Tenn.

## *Indicating Lamps*

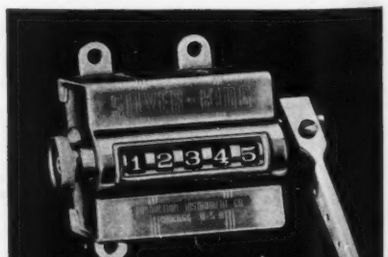
Molded plastic unit for use in indicating lamp service, panelboards, switchboards, annunciators, and similar applications, has an extremely small lens diameter which makes it suitable for applications where larger units cannot be used. It is so constructed as to allow a full 180 deg. of light over the lens cap. Plastic shell and lens-cap are molded in the same color, making each unit a matched set and reducing the danger of inserting a lens cap of the wrong color. Available colors are red, green, amber, blue and milky white. On all standard low voltages up to 48 volts, the T2 unit is used without a resistor assembly. For service on higher voltages, a standard resistor is used



with the unit. A split resistor is available on a 3-wire electrical circuit, which allows a dull glow to be evident at all times, switching to a brilliant light on actual indicating service. H. R. Kirkland Co., Morristown, N. J.

## *Mechanical Counter*

Each operating function of this new mechanical counter has been thoroughly studied and perfected. Heavy number wheels are replaced by Bakelite, reducing by 85 per cent the weight that must be started and stopped with every count. Unbreakable windows of reinforced plastic material are streamlined to avoid shadows. Rugged steel case is chromium plated. In testing, the new Silver King counted at the rate of 60,000 per hour, and on long runs at 36,000 per hour. Production Instrument Co., 700-06 W. Jackson Blvd., Chicago, Ill.



# Manufacturers' Publications

## Materials

PLASTICS—E. I. du Pont de Nemours & Co., Inc., 626 Schuyler Ave., Arlington, N. J. "Parade of Plastics," 8 pages, 8½x11 in. High-spots the story of the origin of many plastic types, including a description of their characteristics and many of their present uses.

PLASTICIZERS AND RESINS — Monsanto Chemical Co., St. Louis, Mo. Booklet, 40 pages, 8½x11 in. Sets forth the essential characteristics of certain plasticizers and resins made by Monsanto, giving a working basis for the selection of the proper one for any particular purpose.

SILVER BRAZING ALLOYS—Handy & Harman, 82 Fulton St., New York. Folder, 4 pages, 8½x11 in. Descriptive of Sil-Fos and Easy-Flo Brazing alloys, this bulletin illustrates many typical applications.

## Mechanical Parts

AIR COMPRESSORS — Sullivan Machinery Co., Michigan City, Ind. Bulletin A-33, 12 pages, 8½x11 in. Gives specifications for and completely describes the new Sullivan Type Q compressors for applications where small units are desired.

BALL BEARINGS—McGill Mfg. Co., Bearing Div., Valparaiso, Ind. Bulletin DM-40, 4 pages, 8½x11 in. Gives complete engineering information covering the new maximum capacity double row ball bearing series.

BALL BEARINGS — New Departure Div. General Motors Corp., Bristol, Conn. Leaflet A-287, 1 page, 8½x11 in. Describes and lists radial load ratings for vertical tension pulley bearings Type TP-13-500.

BEARINGS—The Gwilliam Co., 360 Furman St., Brooklyn, N. Y. Catalog 17, 16 pages, 8½x11 in. Illustrates and describes roller thrust bearings, ball thrust bearings, step bearings, journal roller bearings, industrial roller bearings and special bearings. Standard prices are listed in tabulated form.

BRONZE BEARINGS—Johnson Bronze Co., New Castle, Pa. Bearing data sheets, each 1 page, 8½x11 in. First three of a series of sleeve bearing data sheets cover method of installation, operating temperature, and chemical and physical characteristics of Ledaloy self-lubricating bearings.

BRONZE BEARINGS — Moraine Products Div., General Motors Corp., 1540 Wisconsin Blvd., Dayton, Ohio. Tool list, 71 pages, 8½x11 in. Gives much valuable engineering data for and lists bearing sizes of Durex porous bronze bearings.

CABLE CONNECTORS — Electroline Co., 4121 S. La Salle St., Chicago, Ill. Bulletin F-2, 8 pages, 8½x11 in. Describes installation methods and lists the several corrosion-resistant finishes and types available in various sizes of the improved Electroline-Fiege wire rope connectors.

FLEXIBLE COUPLINGS—Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill. Catalog 1845, 12 pages, 8½x11 in. Contains complete price and dimensional data on Types A, B, and RC couplings, together with information on casings for the RC type.

VALVES — York Oil Burner Co., Inc., York, Pa. Bulletin No. 40040, 4 pages, 8½x11 in. Describes and illustrates the York-Heat iris shutter metering valve.

## Electrical Parts

CAPACITORS—Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa. Leaflet 49-275, 8½x11 in. Describes internally water-cooled Inerteen capacitors for high frequency service. Diagrams, typical application problems and tables demonstrates the capacitor's uses.

CIRCUIT BREAKER — Heinemann Circuit Breaker Co., Trenton, N. J. Leaflet 6¼x7 in. Illustrates and gives brief description of the "Re-Cirk-it" electromagnetic auxiliary breaker for small motor protection.

INSULATING PRODUCTS—American Phenolic Corp., 1250 Van Buren St., Chicago, Ill. Catalog 62, 40 pages, 8½x11 in. Illustrates, describes and gives engineering data for the complete line of Amphenol electrically insulated products.

INDUCTION MOTORS—Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. Descriptive data 3705, 4 pages, 8½x11 in. Type CS squirrel cage induction motors, 250 hp. and larger. Describes, gives recommendations and applications for, and illustrates motors of various frame classifications.

MOTORS — Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. Leaflet F8537, 2 pages, 8½x11 in. Describes Type FS polyphase squirrel cage induction motor, designed especially for constant speed applications requiring normal or high torque characteristics.

PANEL INSTRUMENTS—Roller-Smith Co., 1766 West Market St., Bethlehem, Pa. Catalog 4120, 8 pages, 8½x11 in. Gives specifications for and illustrates Panel Type 3 in. and 4 in. instruments. Dimension diagrams are included.

PRECISION SWITCHES—Mu-Switch Corp., Canton, Mass. Catalog, 10 pages, 8½x11 in. Basic design data, supplemented by stroboscopic photographs to illustrate the principle of the Mu-Switch. Dimensioned drawings of the 16 styles available are included.

SERVICE CENTERS — Trumbull Electric Mfg. Co., Plaineville, Conn. Briefly describes the entire line of Trumbull Multi-Breaker Load and Service Centers, covering five different types of equipment.

TUBING—Irvington Varnish & Insulator Co., 24 Argyle Place, Irvington, N. J. Bulletin, 6 pages, 8½x11 in. Covers nine outstanding features of the new extruded tubing called Type XTE-30, and contains samples, gives sizes, specific colors, and lists prices.

## Finishes

CHEMICAL COATINGS—Interchemical Corporation, 75 Varick St., New York, N. Y. Motion picture, all color, with sound. Titled, "More Than Meets the Eye," this colored movie describes the sale influence of colored chemical coatings. Available for showings to manufacturers, associations, or other interested groups.

## Miscellaneous

BEARING LUBRICATION—Tide Water Associated Oil Co., 17 Battery Pl., New York, N. Y. "Principles of Plain Bearing Lubrication," 16 pages, 8½x11 in. A comprehensive presentation of modern lubrication practices as applied to plain bearings.

FLUORESCENT LIGHTING—Benjamin Electric Mfg. Co., Des Plaines, Ill. Handbook, 46 pages, 8½x11 in. Charts, diagrams, tables and photographs present the data needed to determine how and where to use fluorescent lighting to best advantage.

HEAT CONTROLS — Burling Instrument Co., 241 Springfield Ave., Newark, N. J. Bulletin, 4 pages, 8½x11 in. Illustrates, gives specifications for, and describes laboratory and industrial heat control and temperature limit switches.

PHOTOMETER—Photovolt Corp., 10 E. 40th St., New York, N. Y. Technical bulletin, 8 pages, 8½x11 in. This booklet gives a complete technical description, with illustrations, of the new Photrix small-spot photometer designed particularly for measuring low values of illumination on small areas.

THERMOCOUPLES — Wheelco Instruments Co., 1929 So. Halsted St., Chicago, Ill. Bulletin S2-2, 16 pages, 8½x11 in. Lists and describes thermocouples, thermocouple wire, lead wire, insulators, protecting tubes, and their accessories, supplemented with recommendations for selecting thermocouples, lead wire and protecting tubes.

WELDING ELECTRODES—Lincoln Electric Co., Cleveland, Ohio. Wall chart gives properties of, describes welding procedure with, and lists sizes and ampere ranges for various kinds of arc welding electrodes.

# Books and Bulletins

## *Modern Steels*

EDITED BY ERNEST E. THUM—*359 pages, plus index, 150 illustrations, 6 x 9 in. Red cloth binding. Published by The American Society for Metals, Cleveland, Ohio.*

Manufacture, inspection treatment and uses of steels are given complete treatment in this new book, a result of a series of lectures presented before the Pittsburgh chapter of the A.S.M. The chapters cover raw materials and pig iron, steel making processes, steel pouring, hot working, inspection and testing, metallography, heat treatment, alloy steels, stainless steels and tool steels. The lectures were delivered by a group of well-known metallurgists and cover the fundamentals of metallurgy in simplified form.

## *Mechanics Applied to Vibrations and Balancing*

D. LAUGHARNE THORNTON—*529 pages, 6¼x9¾ in., 187 illustrations. Green clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York. Price $7.50.*

This volume treats the general theory of vibration in its various aspects and relations to the design of mechanisms, machinery and structures as influenced by disturbing forces set up by dynamic inertia effects. The principles and equations developed are amply supplemented with applications and complete solutions of examples. In presenting the subject, the author has assumed that the reader would have a knowledge of calculus and analytical geometry.

In the section devoted to balancing of engines, the author analyzes the dynamical forces present in horizontal, vertical, vee, radial and offset engines. Balancing locomotives is covered in detail. In developing the general theory of vibrations, the conditions of equilibrium and stability are fully dealt with, and the principles applied to structural frames, airscrew blades, engine-driven alternators and nose-suspended motor drives.

The subject of propagation of stress in elastic materials receives its share of attention, and is illustrated by its influence on reinforced concrete, elastic hysteresis and internal friction of metals, torque in shafts and heavy couplings, water hammer, condensers, and fuel systems of internal combustion engines. Vibrations and their nature as related to beams, plates, shafts, disks, and gearing are analyzed.

The book concludes with a 46-page general survey of many engineering structures and geophysical phenomena which can be studied by an application of the general theories developed throughout the book.

## *The Electric Power Engineers' Handbook*

W. S. IBBETSON—*241 pages, 110 illustrations, 5½ x 8½ in. Blue cloth binding. Published by Chemical Publishing Co., 148 Lafayette St., New York City.*

A practical handbook designed to provide the information for proper application and servicing of electrical machinery. For the engineer whose duties entail design work and supervision of electrical machinery, this book will prove a good source for reference data. Chapters deal with generators, a.c. and d.c. motors, dynamo operation, alternator operation, converter plant operation, faults, breakdown and testing, accumulators and a chapter of mechanical engineering hints.

## *The Story of Superfinish*

ARTHUR M. SWIGERT, JR.—*672 pages, illustrated, indexed, 6½ x 9⅜ in., maroon clothboard covers. Published by Lynn Publishing Co., Detroit, Mich. Price $5.*

The industrial development of metal surface finishing over the last few decades, with particular emphasis on superfinishing, is covered in this text. This refined method of metal surface finishing, christened "superfinish," is a direct outgrowth of Chrysler research started in 1934 to eliminate brinelling of automobile bearings. Superfinishing, as conceived by Mr. D. A. Wallace, is the removal from the surface of a dimensionally finished metal part fragmented metal resulting from turning, grinding, honing and lapping. The amount removed is usually less than 0.0001 in. in depth. The book contains discussions of the history, metallurgy and engineering possibilities.

### *Refractories Investigations*

*16 illustrations, 20 pages, 6x9 in. Published by Mellon Institute, 4400 Fifth Ave., Pittsburgh, Pa.*

This well illustrated bulletin reports the investigations in refractories being conducted at Mellon Institute on the American Refractories Institute's Multiple Industrial Fellowship. Details of the research are not given, the booklet being merely a resumé of what is being done.

### *Hairlining of Sheet Steel Enamels*

B. J. SWEO—*20 pages, 6x9 in. Published by Technical Staff, Ferro Enamel Corp., Cleveland, Ohio.*

This technical bulletin is a report of an original investigation conducted in Ferro Enamel's research laboratories by Mr. Sweo. To reproduce the conditions under which hairlining occurs in porcelain enameling production, test specimens of 20-gage enameling iron were coated and fired in contact with a baffle frame. Results of the tests, which showed that hairlines are formed by the conditions of strain established within a piece by heating, and are only formed when more than one coat is applied, are tabulated.

### *V-Belt Guide*

*95 pages, 8½x11 in. Paper covers. Published by the L. H. Gilmer Co., Tacony, Philadelphia, Pa.*

New horsepower ratings for multiple V-belts are among the features contained in this new book, which is titled, "Guide to Efficient V-Belt Practice." Multiple and fractional horsepower V-belts are both included in this one book. It contains a complete section of sheave information that covers flat pulley for V-to-flat drives, and adjustable diameter and companion sheaves. It should be to any engineer a useful handbook on complete V-belt drives.

### *Plating With Gold*

*12 pages, 6 x 9 in. Paper Covers. Published by Baker & Co., Inc., 113 Astor St., Newark, N. J.*

Beginning with a brief outline of the development of commercial gold plating salts, this booklet goes on to describe the equipment necessary, the preparation of the work, and gives formulas and procedures for the various types of gold plating baths. The booklet is intended to serve only as a guide, in which capacity it can be useful to engineers who specify plating finishes.

# RESISTORS IN PARALLEL

CARL P. NACHOD, *Vice-President*
*Nachod & United States Signal Company*

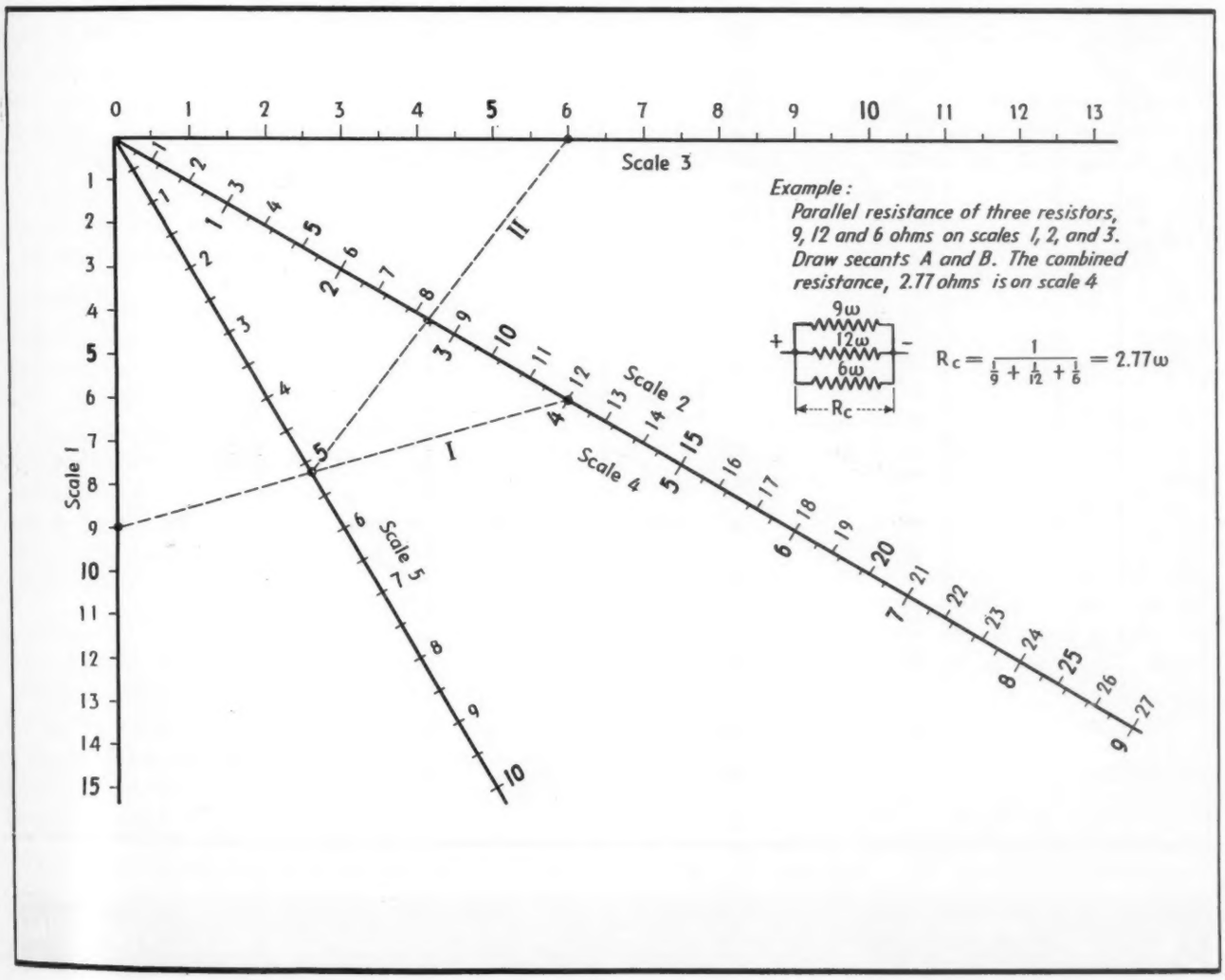
WHEN RESISTANCES are connected in multiple (or parallel) so that the current divides and passes through them simultaneously, then for any number of resistors, the resistance of the combination is the reciprocal of the sum of the reciprocals of each resistor. This nomograph easily computes the combined resistance when two lines are drawn.

Where three resistors connected in parallel have values of 9, 12 and 6 ohms, respectively, draw secant I from 9 on scale (1) to 12 on scale (2), and from where this cuts scale (5) between them, draw secant II to 6 on scale (3). Where this cuts scale (4) between them, at 2.77 ohms is the combined resistance.

The point 5.14 on scale (5), cut by secant I, is the combined parallel resistance of only two resistors. Similarly secant II cuts out on scale (4) the combined resistance of the two resistors on scales (5) and (6). The chart may be used to add a fourth resistor or more by placing 2.77 on scale (1) and the fourth resistor on scale (2).

If it were desired to have a combined resistance of 2.77 ohms, and one of the three resistors in the combination were to be 6 ohms, the corresponding other two can be found by pivoting secant I about the intersection on scale (5) and noting where it cuts scales (1) and (2).

The chart will also solve the problem of liquids in pipes filling a tank; as with the same example, if each separately can fill the tank in 9, 12 and 6 hours respectively, flowing together they will fill it in 2.77 hours.



# DIRECT CURRENT TRANSMISSION

CARL P. NACHOD, *Vice-President*
*Nachod & United States Signal Company*

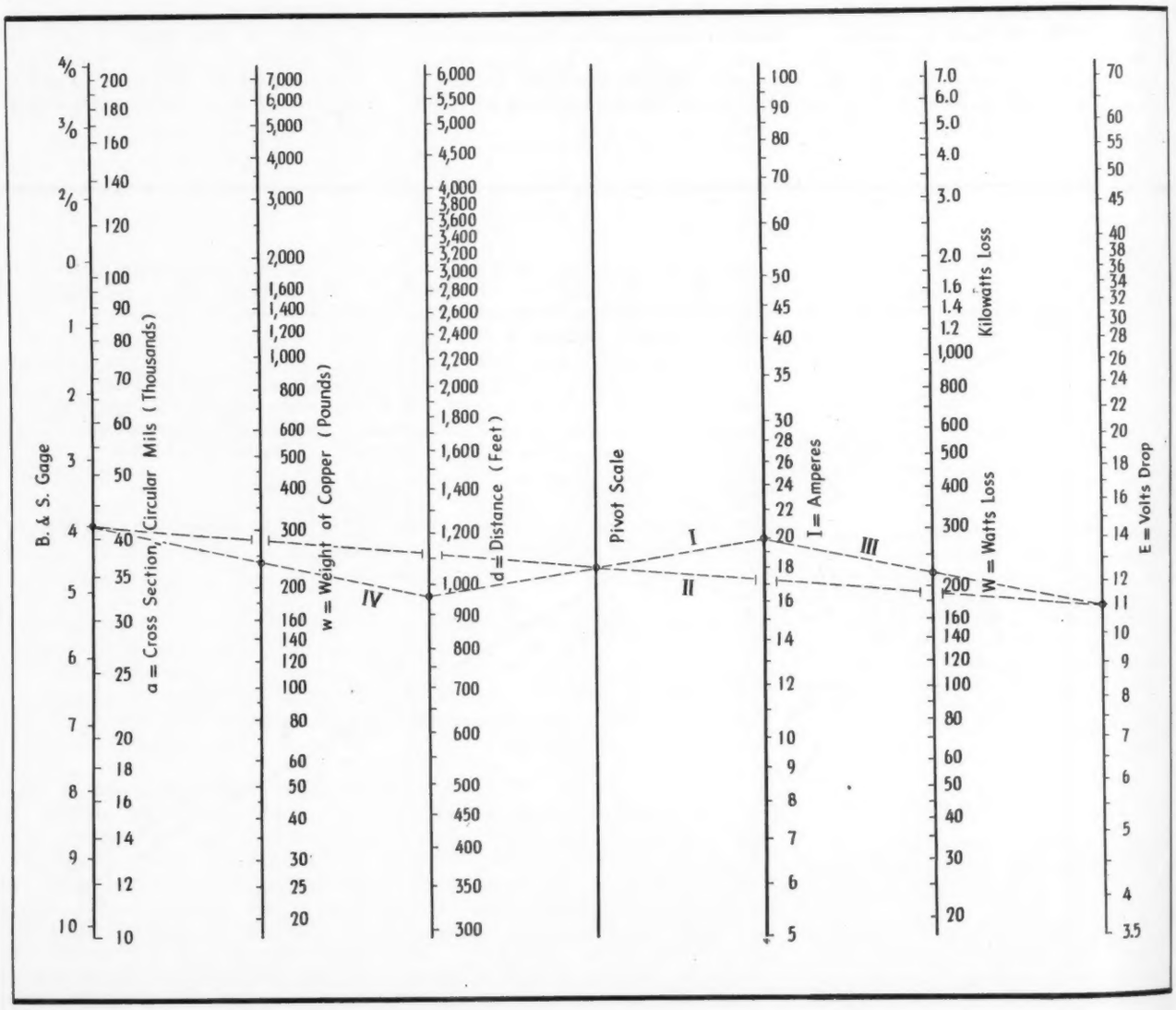
SECANTS I and II of this nomograph determine the size of wire needed to transmit a certain current a definite distance with a given voltage drop. The watts lost in the wire and the weight of wire required, for the same assumed example, are given by secants III and IV, respectively.

Let it be required to transmit 20 amp. a one-way distance of 970 ft. Then secant I is drawn between 20 on the *I* scale and 970 on the *D* scale, intersecting the pivot scale. Now if the permissible voltage drop is 11 volts, draw secant II from this point on the *E* scale through this intersection on the pivot scale, continuing it to the gage scale on the left, which it intersects at No. 4 wire, the required size. By secant III, between 11 on *E* and 20 on *I*, we see that the watts lost are 220 on the *W* scale. By secant IV, between 970 on *D* and No. 4 on gage scale, we see that the weight of wire required is 242 lb.

$$a = \frac{0.0236\ dI}{E} \qquad W = EI$$

$$w = \frac{ad}{157}$$

In the first, the resistivity of the copper has been taken as at 60 deg. C. This is probably warmer than it would reach in practice, but it is on the safe side.




PRODUCT ENGINEERING ✦ REFERENCE BOOK SHEET